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College of Life Sciences and Agriculture

GRANITE STATE GRAZIERS

Annual Forage Crops and Supplementation Strategies for Grazing Dairy Cows

André F. Brito, Veterinarian, M.S., Ph.D.
Associate Professor of Dairy Cattle Nutrition and Management
Department of Agriculture, Nutrition, and Food Systems
University of New Hampshire
Email: andre.brito@unh.edu
Office phone: (603) 862-1341
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Outline

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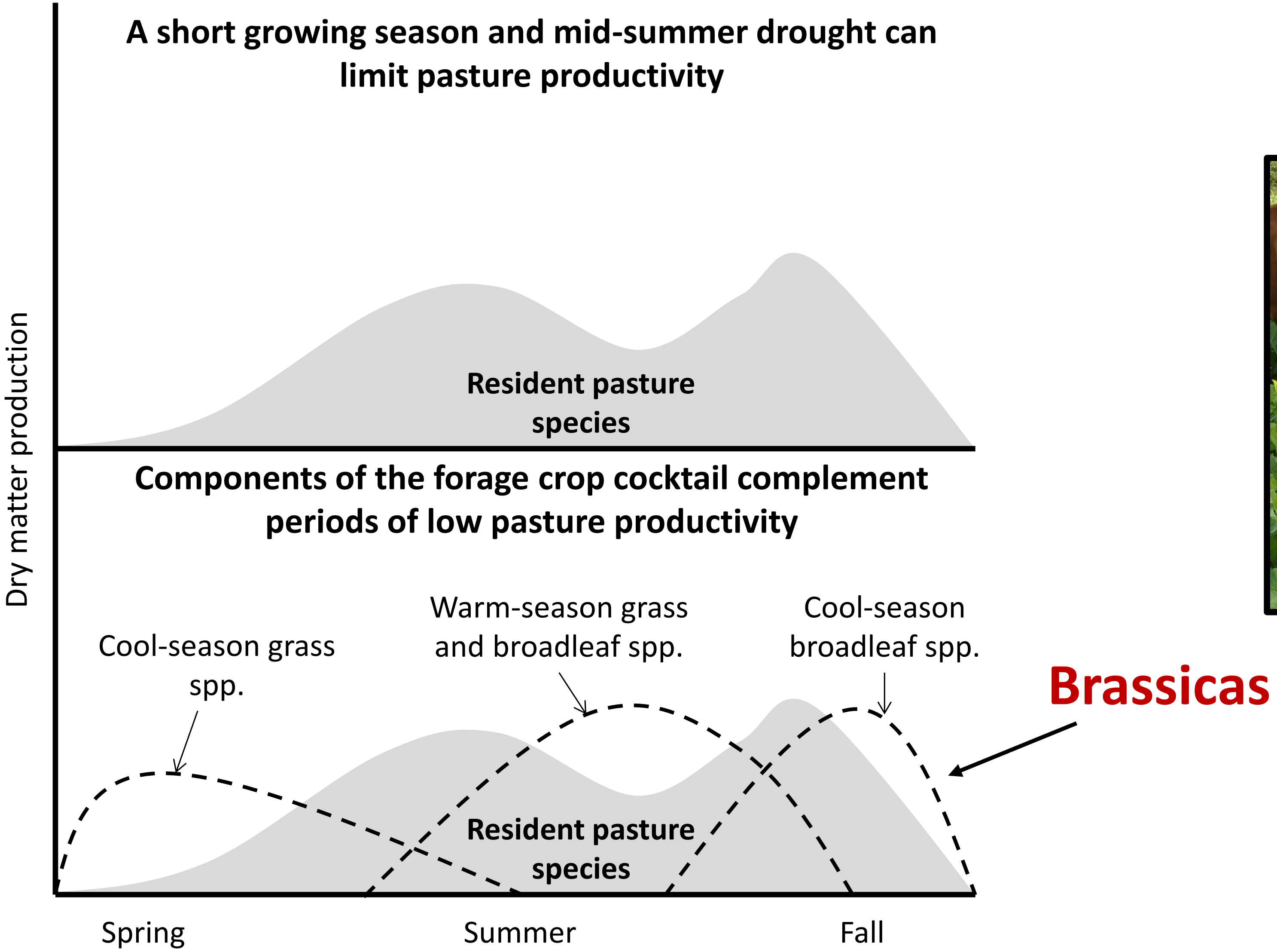
- Use of brassicas for fall grazing
- Use of summer annual mixtures for grazing dairy cows
- Strategies to increase sugars in forages
- Kelp meal supplementation for grazing dairy cows
- Questions

Use of brassicas for grazing



Why brassicas?

- Brassica species include rapeseed, canola, turnip, kale, radish, and swede
- Forage variety trials have shown high biomass potential: 1,330–4,450 lb of DM/acre
- High crude protein (>20%), low fiber (20–35%), and high DM digestibility (>85%)
- Brassicas contain a class of secondary plant metabolites called glucosinolates

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Enteric methane production and ruminal fermentation of forage brassica diets fed in continuous culture[1]

Sandra Leanne Dillard,* Ana I. Roca-Fernández,*,† Melissa D. Rubano,* Kyle R. Elkin,* and Kathy J. Soder*,[2]

*USDA-Agricultural Research Service, Pasture Systems and Watershed Management Research Unit, University Park, PA 16802-3702; and †Depto. Producción Vegetal, Escuela Politécnica Superior, Universidad de Santiago de Compostela, Lugo, España

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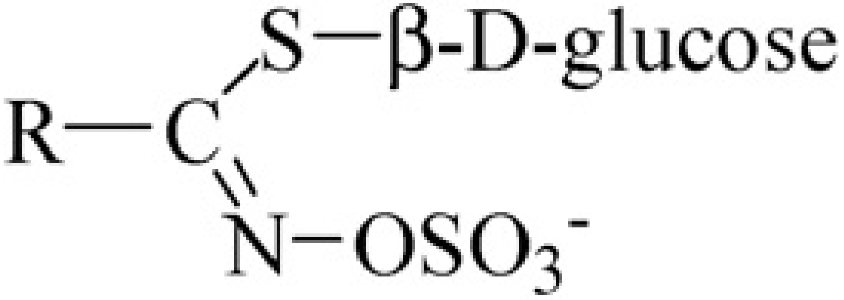
Dual flow continuous culture fermentors

Nutritional composition of grasses vs. brassicas

	Forage sources				
Item	Annual ryegrass	Orchardgrass	Canola	Rapeseed	Turnip
CP, %	30.2	30.4	28.2	23.2	22.2
NDF, %	29.7	41.2	16.1	16.6	17.2
ADF, %	21.2	22.8	10.8	11.8	12.0
Lignin, %	5.3	2.5	0.8	1.3	1.3
Starch, %	0.2	0.3	0.5	1.7	0.2
Sugars, %	19.6	7.9	24.7	24.6	26.9
NE_L, Mcal/lb	0.76	0.73	0.90	0.85	0.81
NE_G, Mcal/lb	0.47	0.45	0.59	0.55	0.51
Ca, %	0.64	0.42	1.78	1.98	2.47
P, %	0.28	0.40	0.36	0.35	0.43

General structure of glucosinolates



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Concentration of glucosinolates in grasses and brassicas

	Ingredient					Diet*			
Glucosinolate†	Annual Ryegrass	Canola	Rapeseed	Turnip	Orchardgrass	ARG	CAN	RAP	TUR
Glucobrassicanapin	0.00	5.72	5.13	17.29	0.00	0.00	2.86	2.57	8.65
Progoitrin	0.00	3.04	9.66	15.26	0.00	0.00	1.52	4.83	7.63
Gluconapin	0.00	1.00	1.42	4.15	0.00	0.00	0.50	0.71	2.08
Glucobrassicin	0.00	0.95	1.25	1.96	0.00	0.00	0.48	0.63	0.98
Gluconasturtiin	0.00	0.68	1.16	3.95	0.00	0.00	0.34	0.58	1.98
Glucoraphanin	0.00	0.16	0.63	0.42	0.00	0.00	0.08	0.32	0.21
Glucoerucin	0.00	0.01	0.05	0.41	0.00	0.00	0.01	0.03	0.21
Sinigrin	0.00	0.08	0.23	0.31	0.00	0.00	0.04	0.12	0.16
Glucoraphenin	0.00	0.04	0.04	0.05	0.00	0.00	0.02	0.02	0.03
Total	0.00	11.68	19.51	43.80	0.00	0.00	5.84	9.76	21.90

*ARG = 50% annual ryegrass + 50% orchardgrass; CAN = 50% canola + 50% orchardgrass; RAP = 50% orchardgrass + 50% rapeseed; TUR = 50% turnip + 50% orchardgrass

Nutrient digestibility of the experimental diets

	Diet*				
Item	ARG	CAN	RAP	TUR	SEM
Apparent digestibility					
DM, %	44.5	44.7	45.3	46.0	2.77
OM, %	61.6	62.5	63.6	65.0	2.84
NDF, %	38.1	52.8	40.9	44.5	5.57
ADF, %	52.1[a]	64.0[b]	48.8[a]	53.9[a]	3.15
True digestibility					
DM, %	70.0	66.4	69.5	62.4	2.86
OM, %	89.7	86.4	90.1	82.6	3.13

*ARG = 50% orchardgrass + 50% annual ryegrass; CAN = 50% orchardgrass + 50% canola; RAP = 50% orchardgrass + 50% rapeseed; TUR = 50% orchardgrass + 50% turnip.

[a–b]Within a row, means without a common superscript differ ($P \leq 0.05$).

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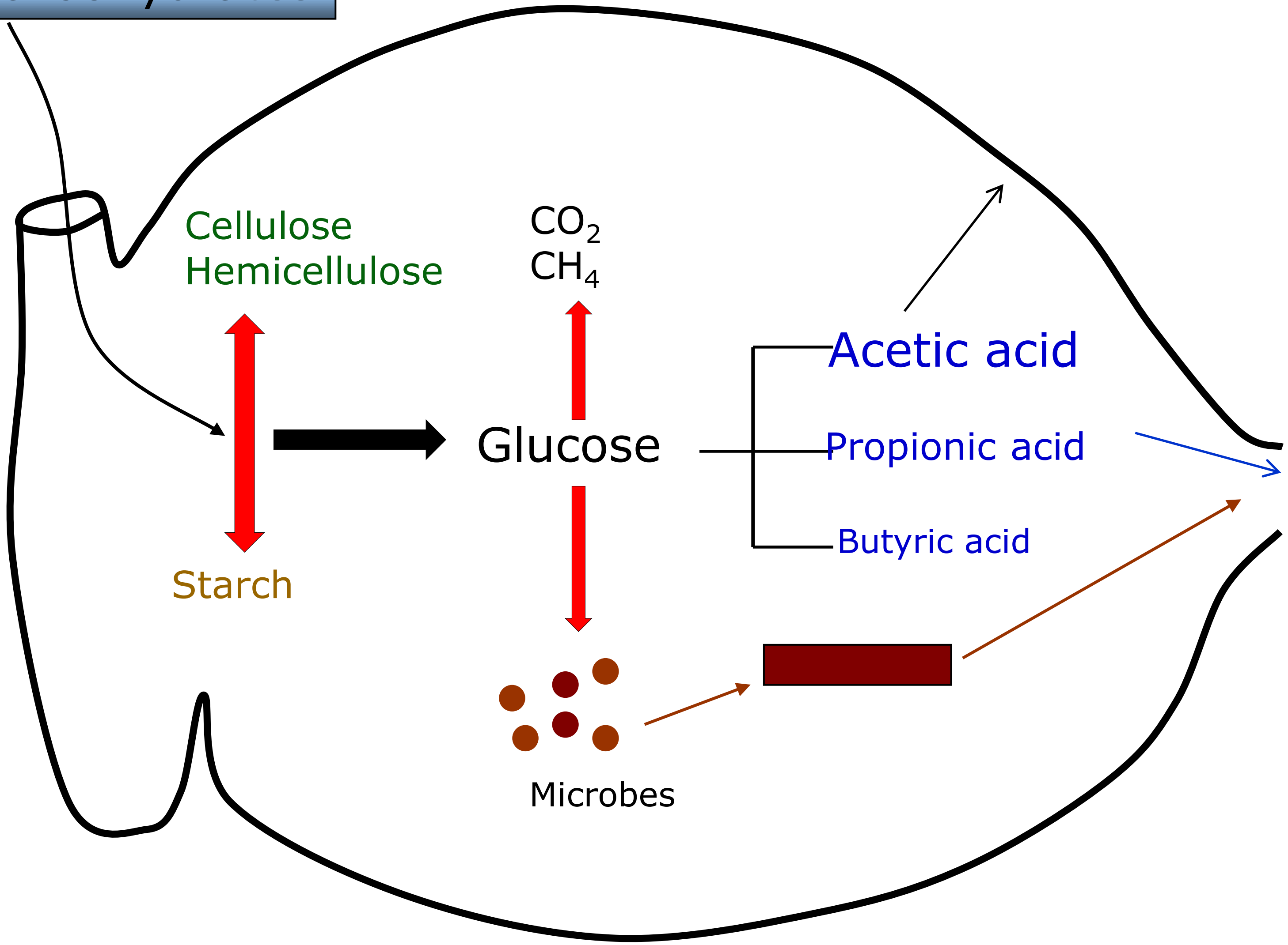
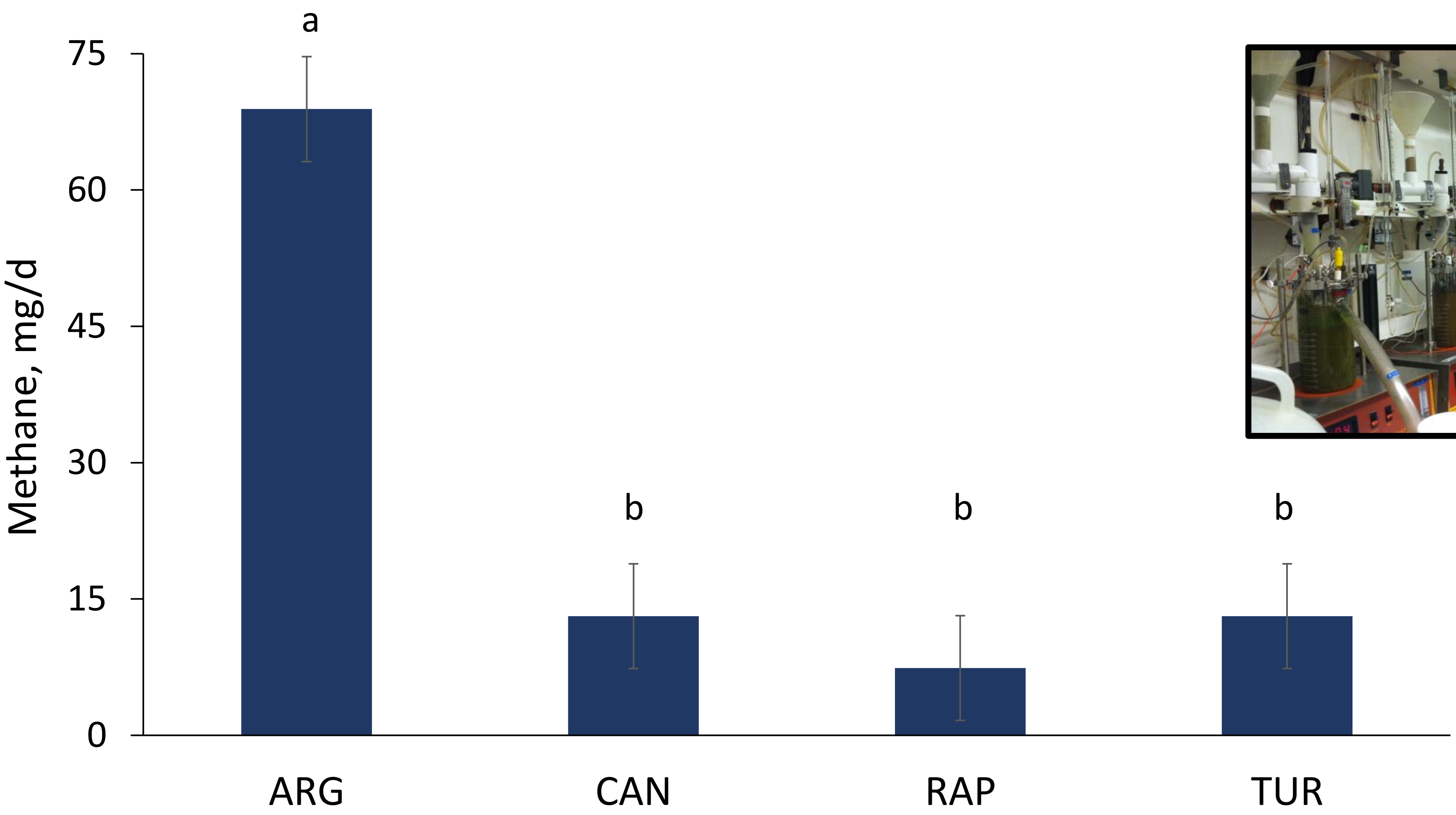
Dietary Carbohydrates



Methane emissions in the experimental diets



ARG = 50% annual ryegrass + 50% orchardgrass; CAN = 50% canola + 50% orchardgrass; RAP = 50% orchardgrass + 50% rapeseed; TUR = 50% turnip + 50% orchardgrass

[a,b]Means without a common letter differ at $P < 0.05$

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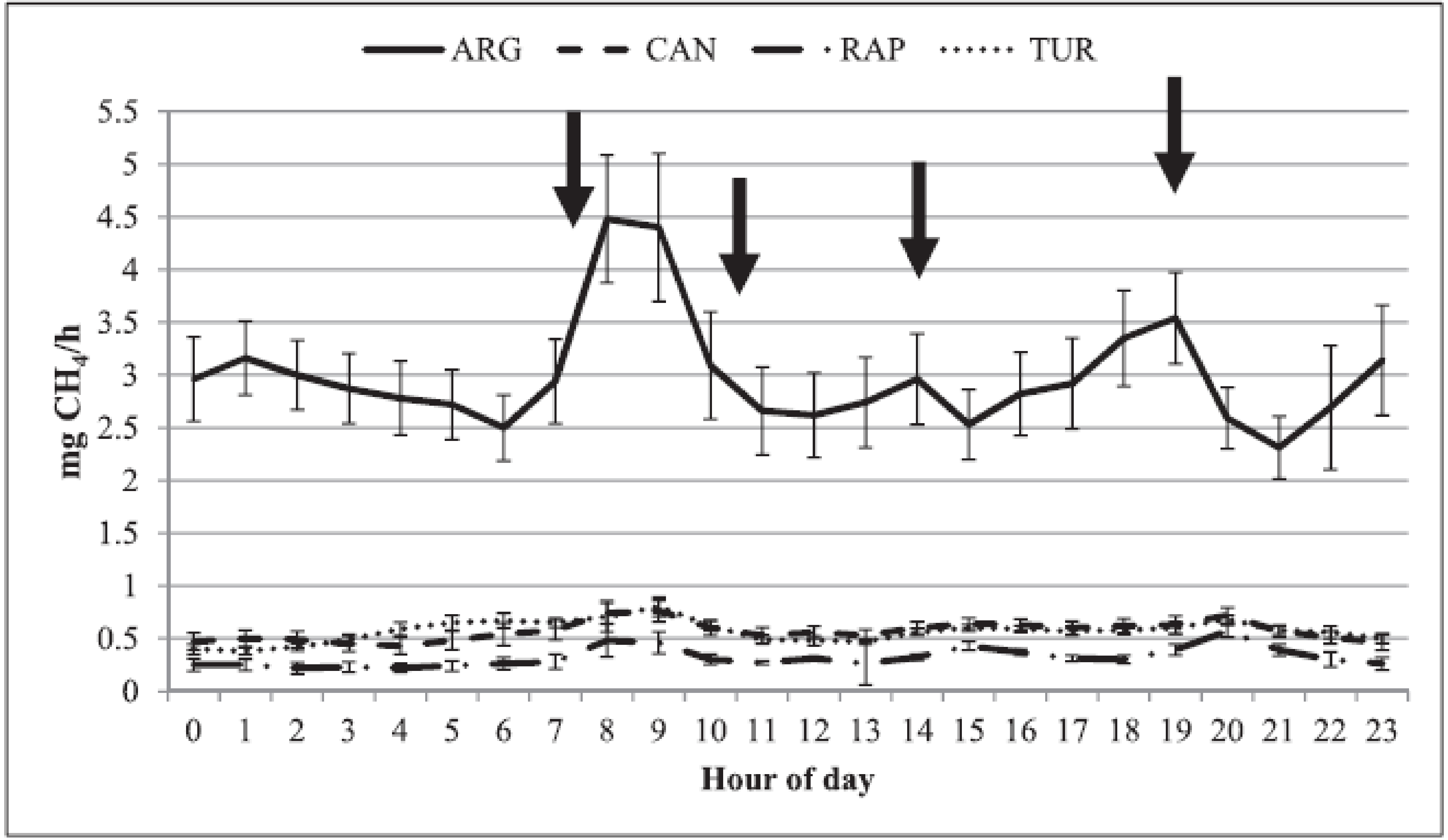
Daily methane production in the experimental diets



ARG = 50% annual ryegrass + 50% orchardgrass; CAN = 50% canola + 50% orchardgrass; RAP = 50% orchardgrass + 50% rapeseed; TUR = 50% turnip + 50% orchardgrass

Correlation between individual or total glucosinolates and methane emissions

Glucosinolate*	r	P value
Glucobrassicanapin	−0.523	0.038
Sinigrin	−0.643	0.007
Glucobrassicin	−0.732	0.001
Glucoerucin	−0.333	0.207
Gluconapin	−0.509	0.044
Gluconasturtiin	−0.456	0.076
Glucoraphanin	−0.670	0.005
Glucoraphenin	−0.787	<0.001
Progoitrin	−0.593	0.015
Total	−0.567	0.022

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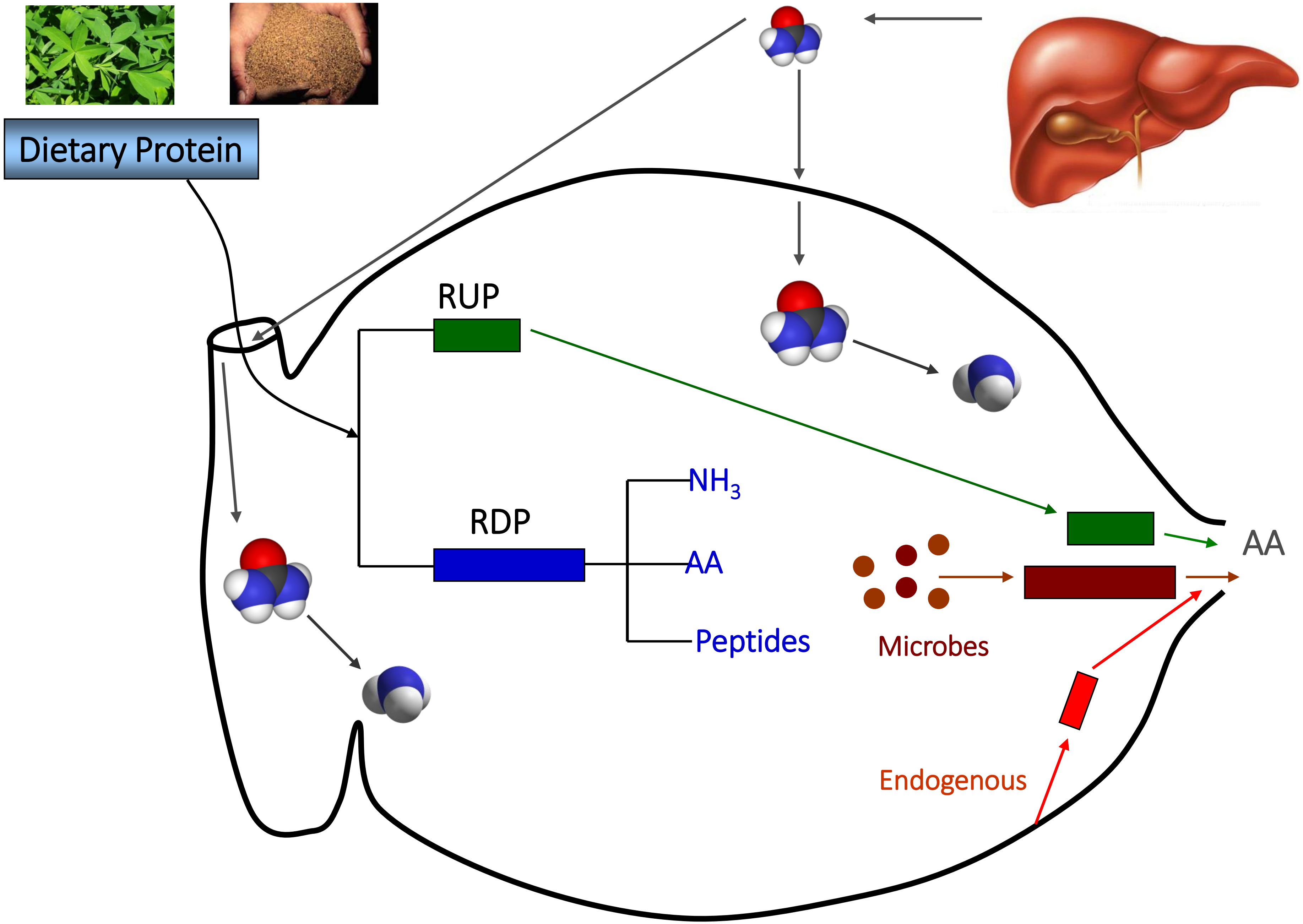

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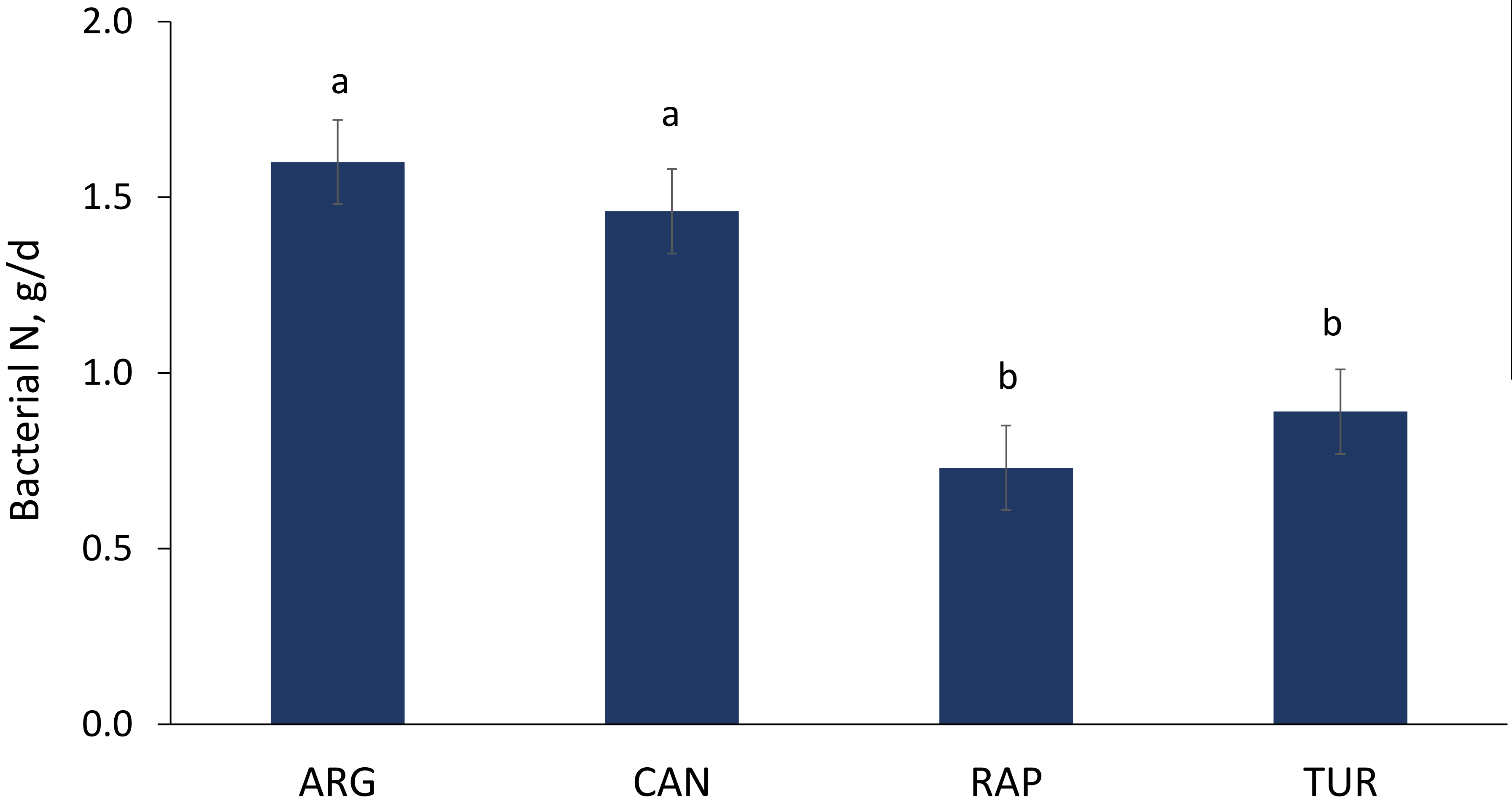
Bacterial N synthesis in the experimental diets



ARG = 50% annual ryegrass + 50% orchardgrass; CAN = 50% canola + 50% orchardgrass; RAP = 50% orchardgrass + 50% rapeseed; TUR = 50% turnip + 50% orchardgrass

[a,b]Means without a common letter differ at $P < 0.05$

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General study procedures

- Eighteen mid-lactation Jersey cows
- Cows were randomly assigned to 1 of 2 diets: **TMR or TMR plus grazed canola (60:40 forage-to-concentrate ratio)**
- Diet was formulated to include 35% (dry matter basis) of canola as grazed forage offered after the afternoon milking
- Cows were milked and fed twice daily
- Feeds, milk, blood, feces, urine, and rumen fluid samples were collected throughout the 6-week study
- Methane was measured using the GreenFeed system

Strip grazing management system

Vertical mixer

TMR mixer

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Calan doors system

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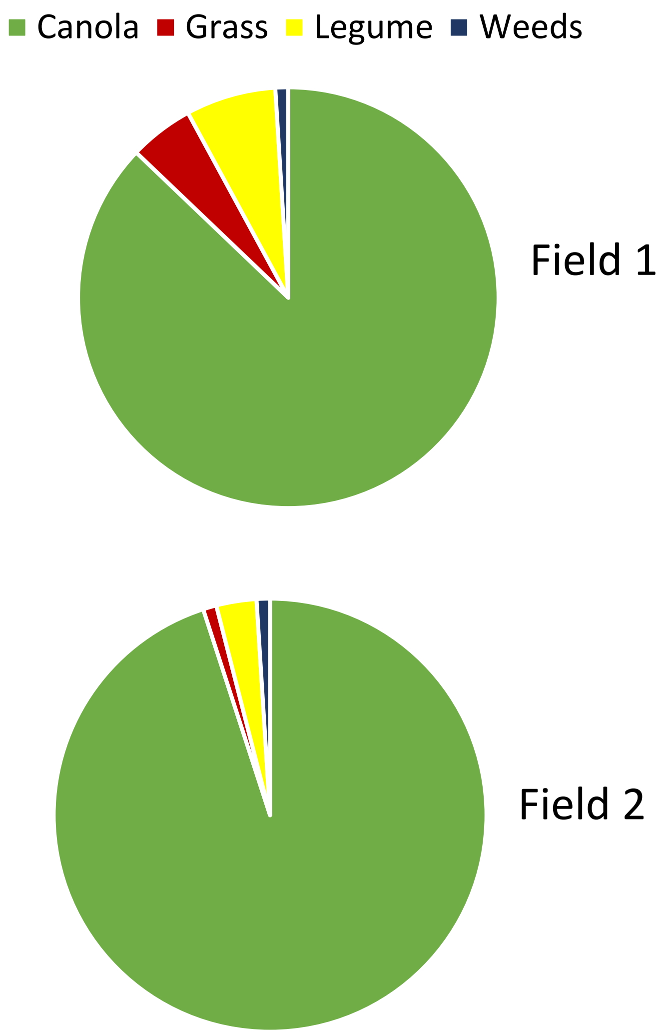
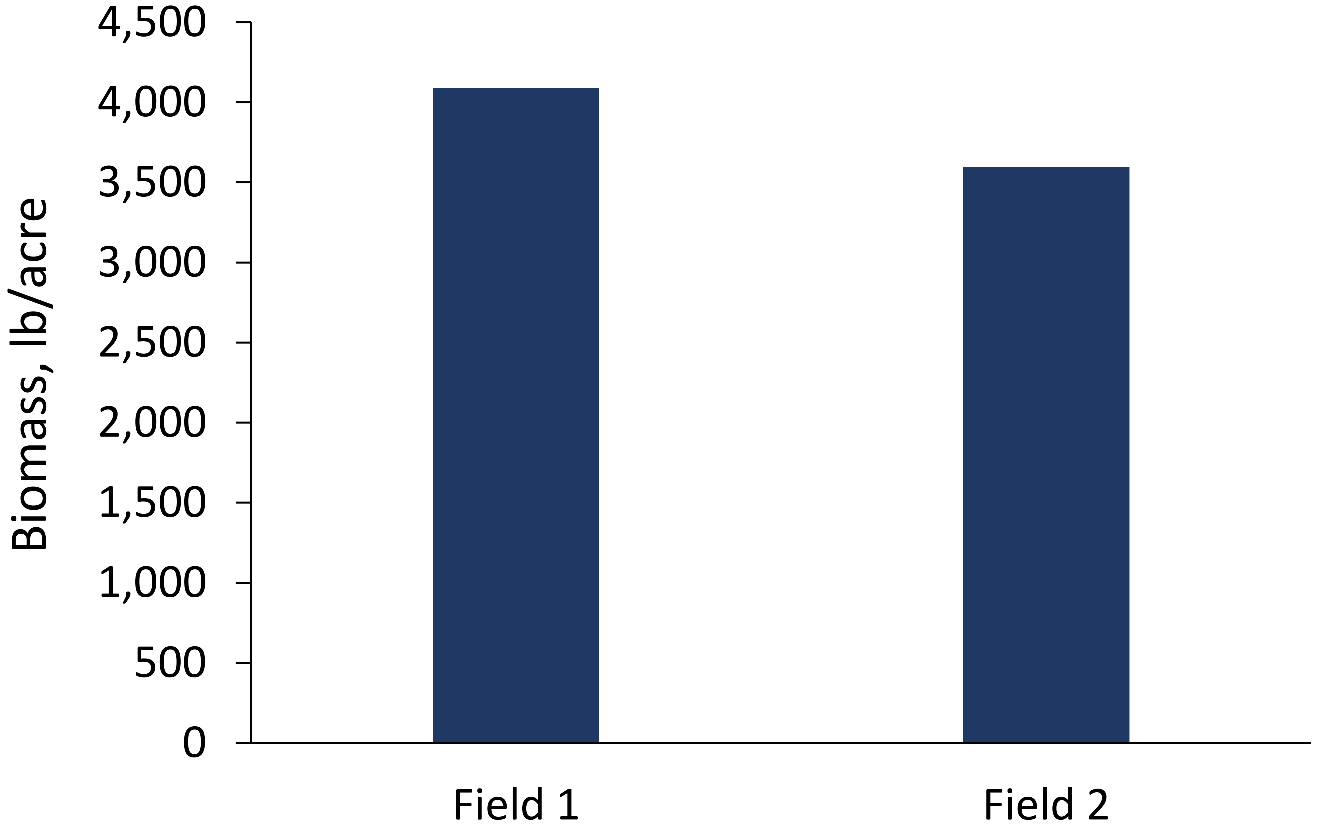
Botanical composition and biomass





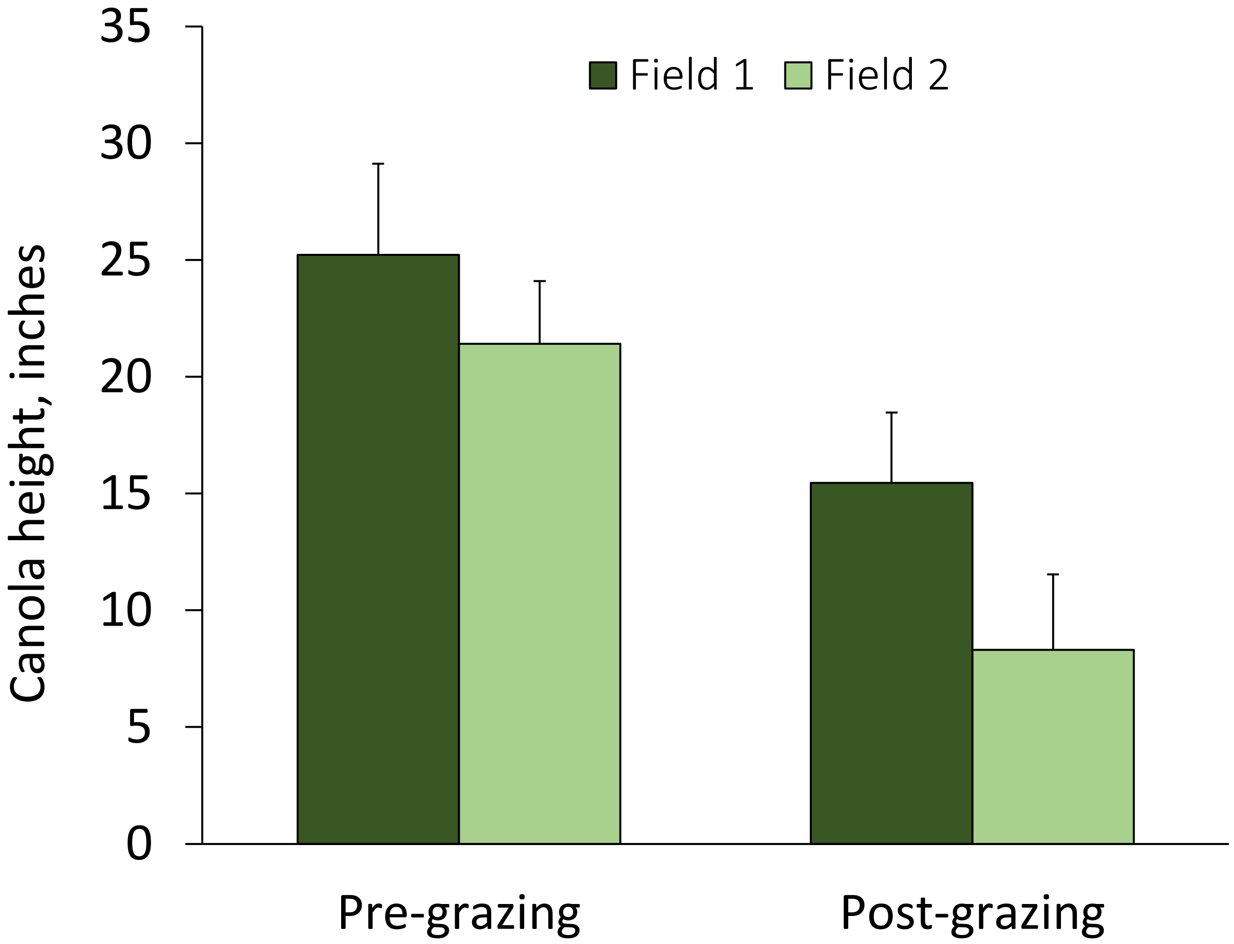
Baleage vs. canola nutritional composition

Item	Feeds	
	Baleage	**Canola**
DM %	45.7	12.1
CP, %	18.3	24.9
NDF, %	51.0	15.6
ADF, %	31.6	12.6
Lignin, %	4.90	1.40
Sugars, %	4.60	21.7
NE_L, Mcal/lb	0.59	0.86
NE_G, Mcal/lb	0.32	0.53

Canola nutritional composition

	Feeds	
Item	**Field 1**	**Field 2**
Dry matter, %	12.1	12.1
CP, %	22.5	27.2
NDF, %	16.2	14.9
ADF, %	12.6	12.6
Lignin, %	1.2	1.6
Sugars, %	22.5	20.8
NE_L, Mcal/lb	0.85	0.83
NE_G, Mcal/lb	0.54	0.52

Pre- and post-grazing heights of canola fields



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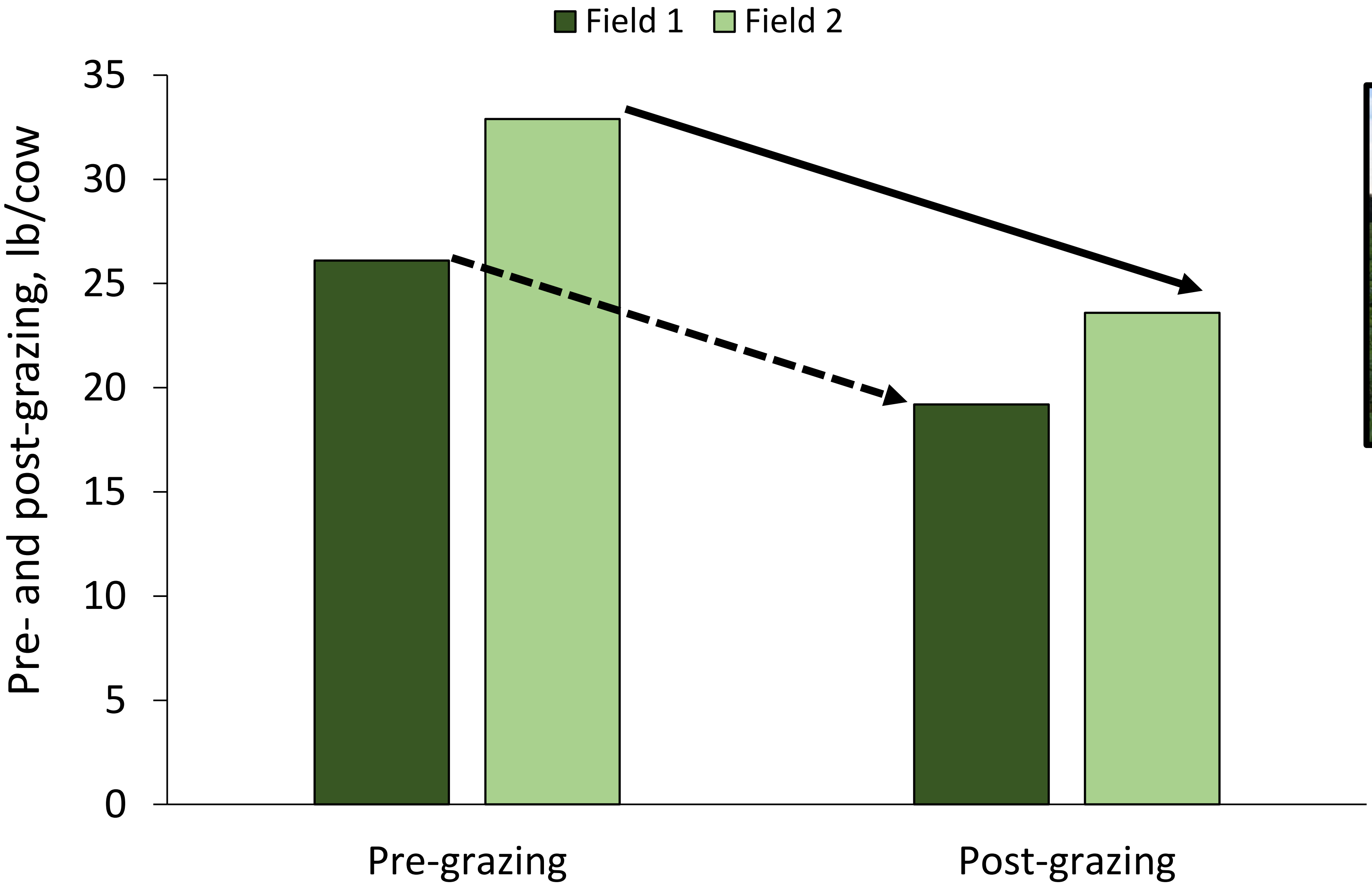
Pre-grazing canola offered and post-grazing biomass



Pre- and postgrazing canola field

Pre- and postgrazing canola field

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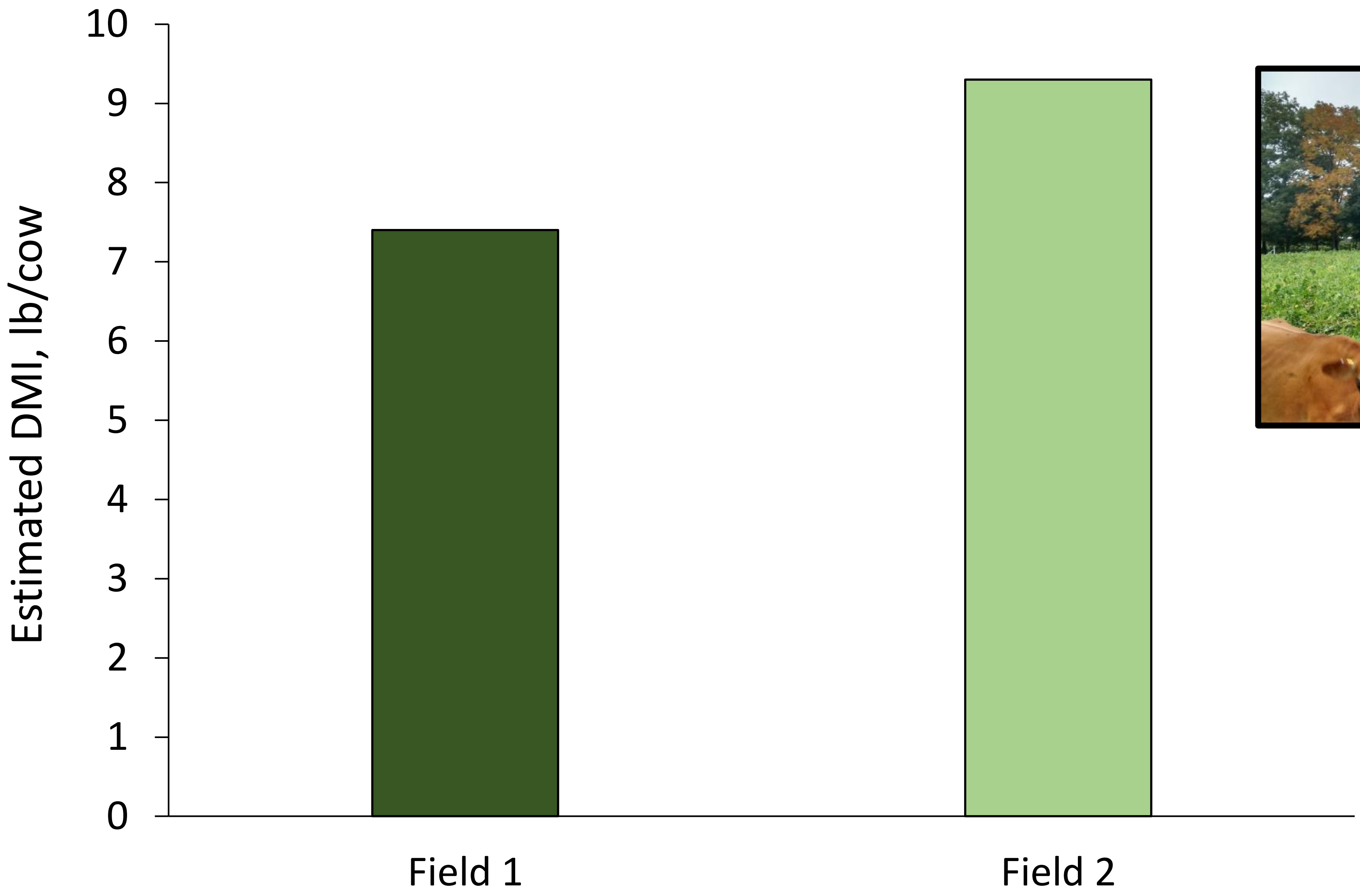
Estimated canola DMI



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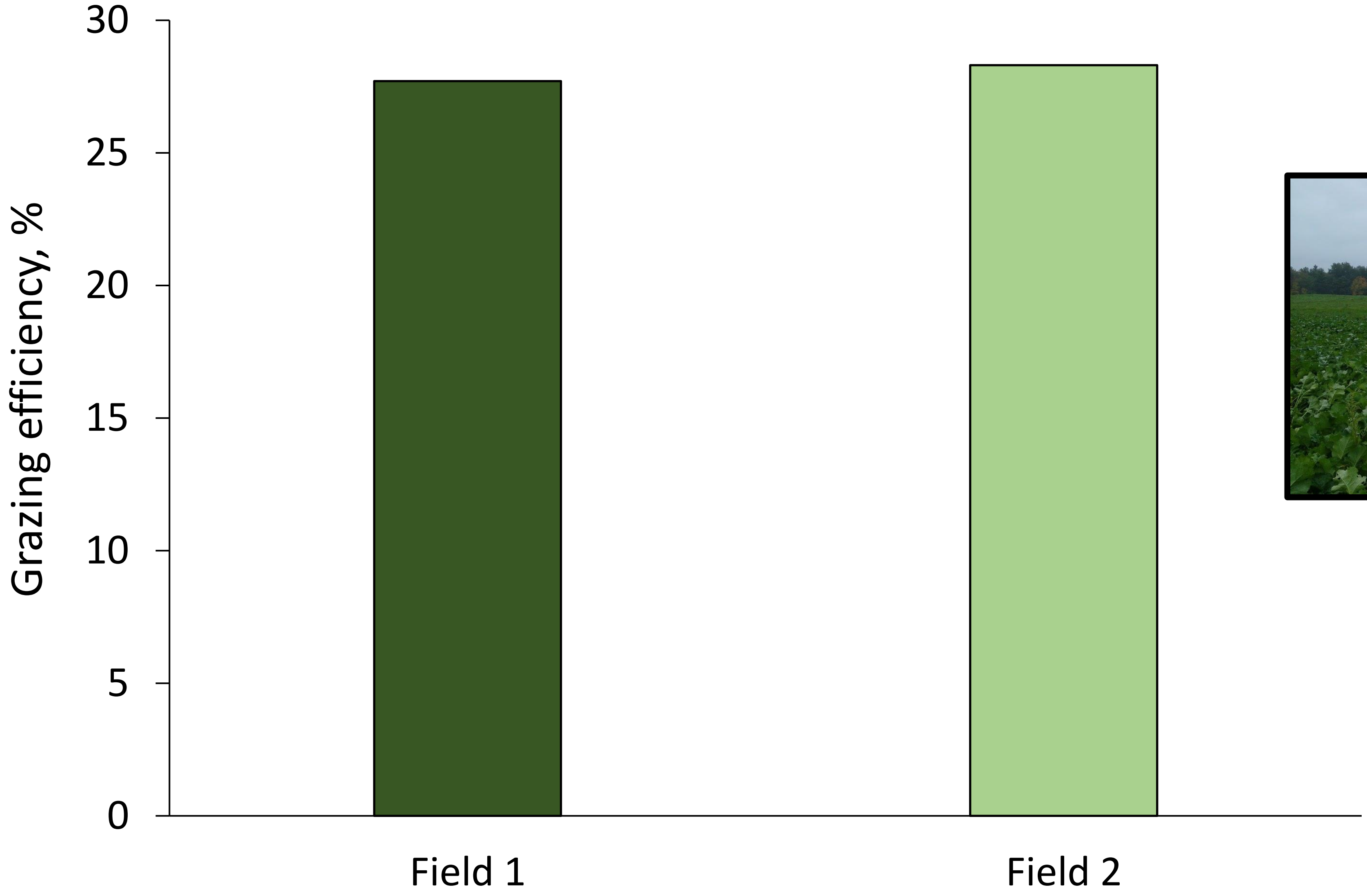
Estimated grazing efficiency



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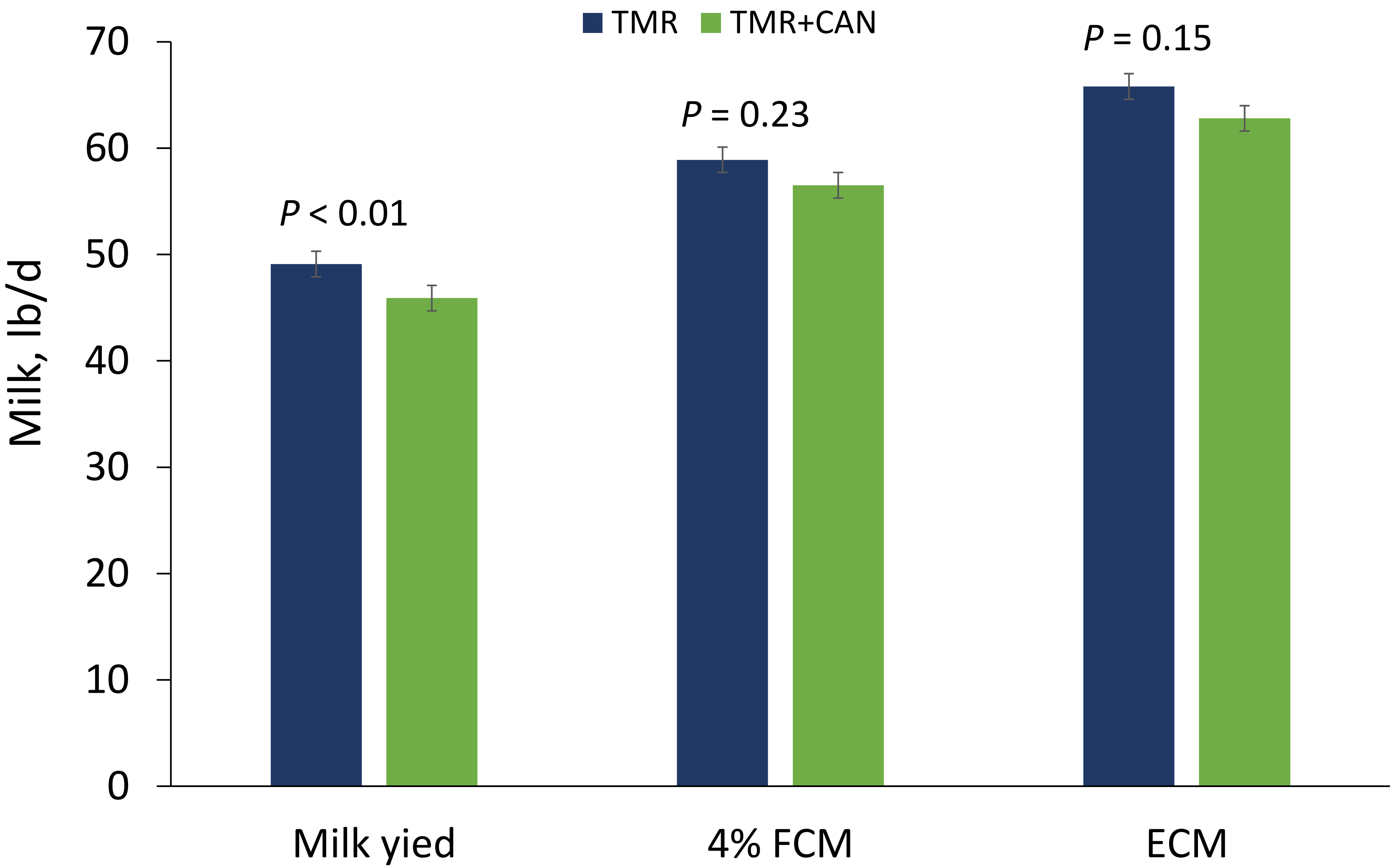
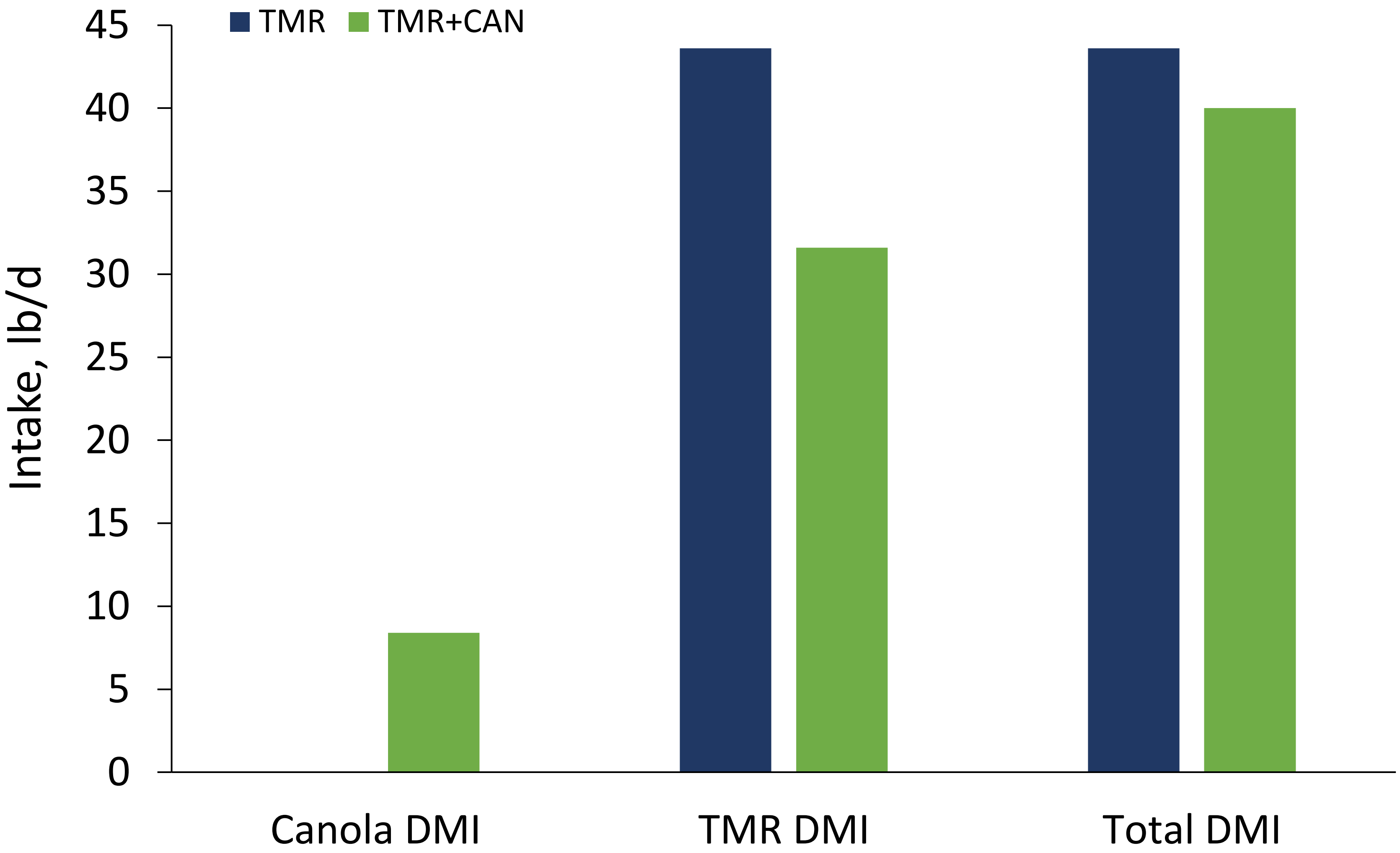
Pregrazing canola field after first frost

Milk production in cows grazing canola



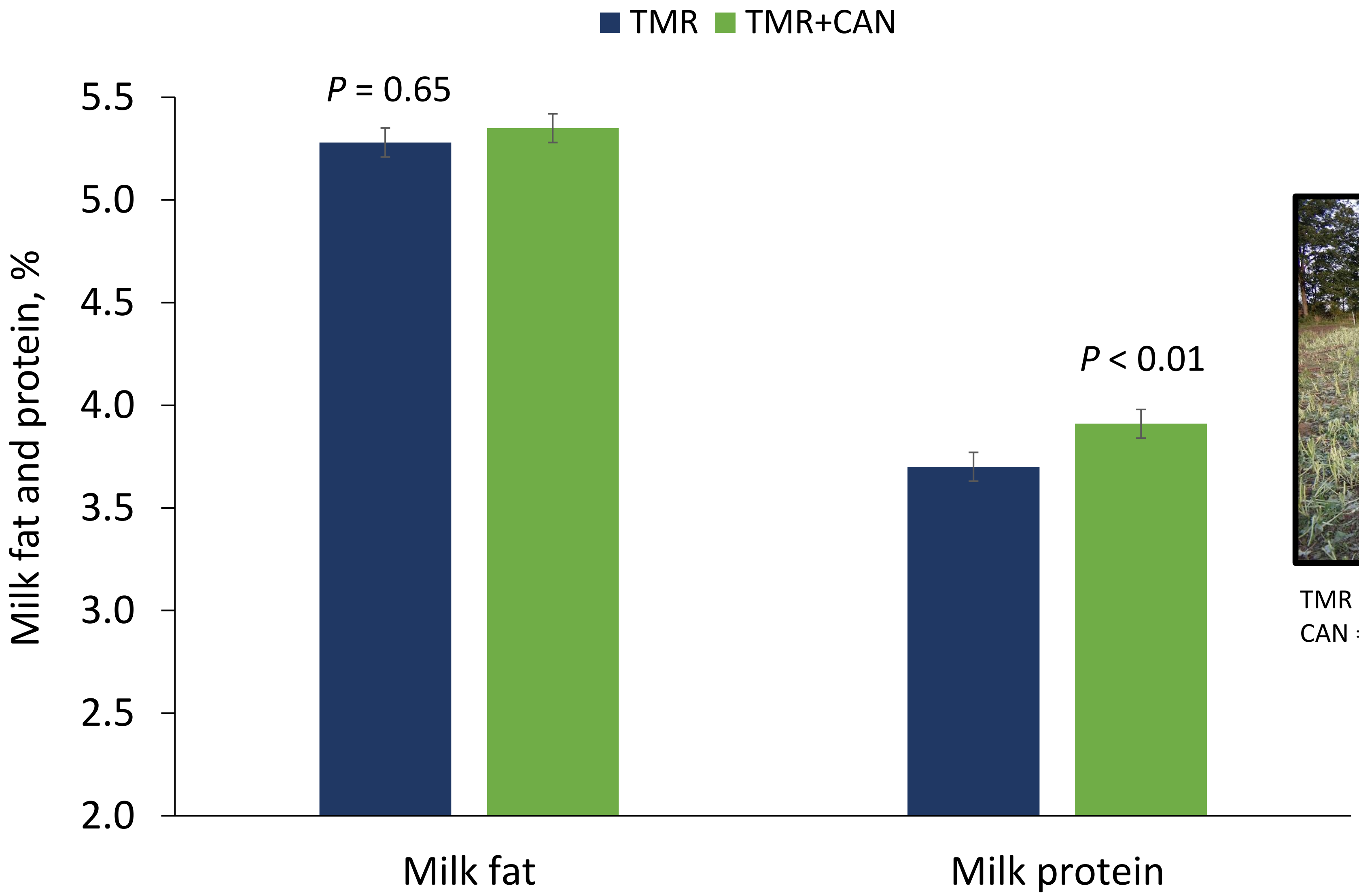
TMR = total mixed ration
CAN = canola
FCM = fat-corrected milk
ECM = energy-corrected milk

Intake in cows grazing canola



TMR = total mixed ration
CAN = canola

Milk fat and protein content in cows grazing canola



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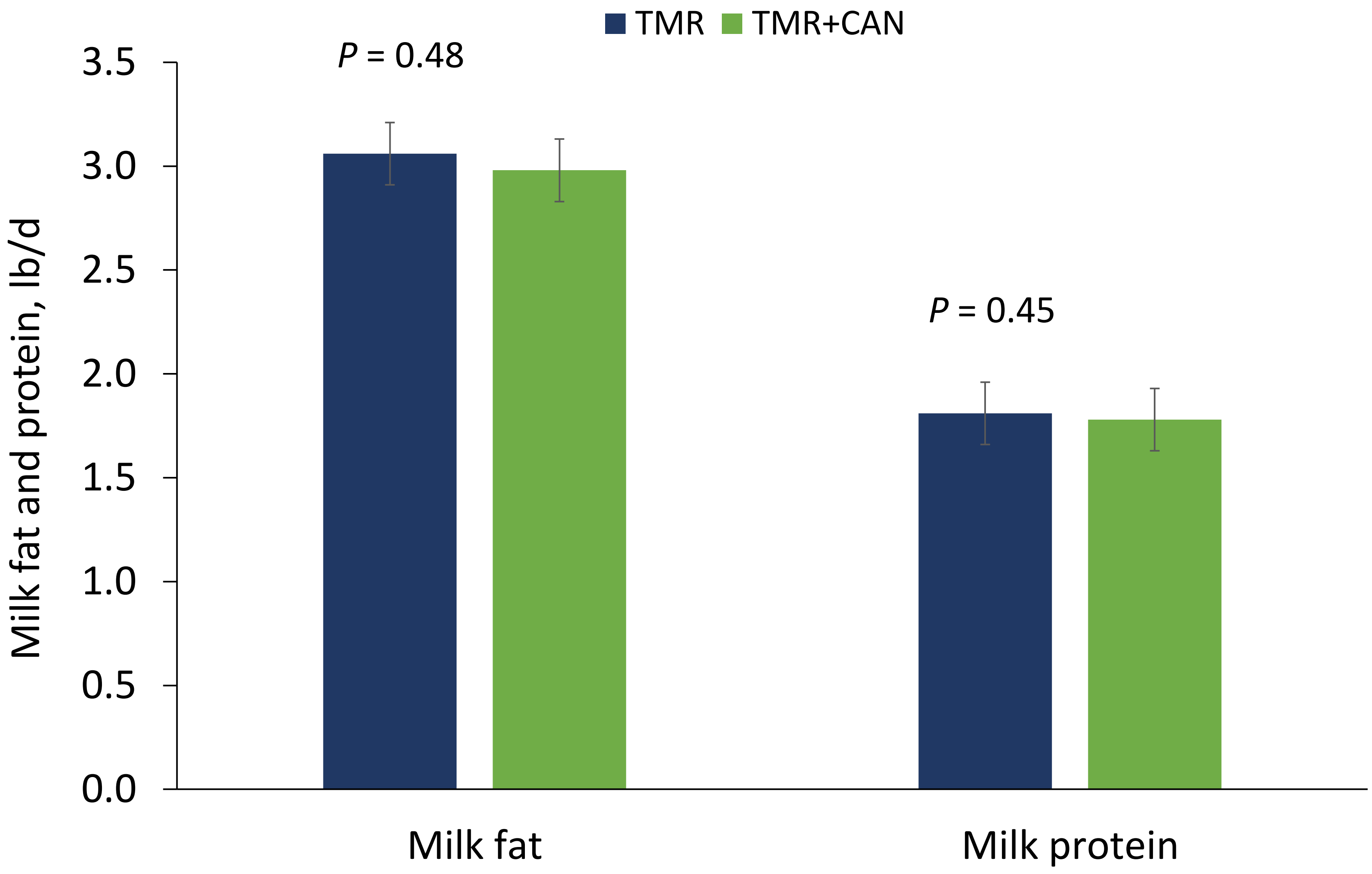
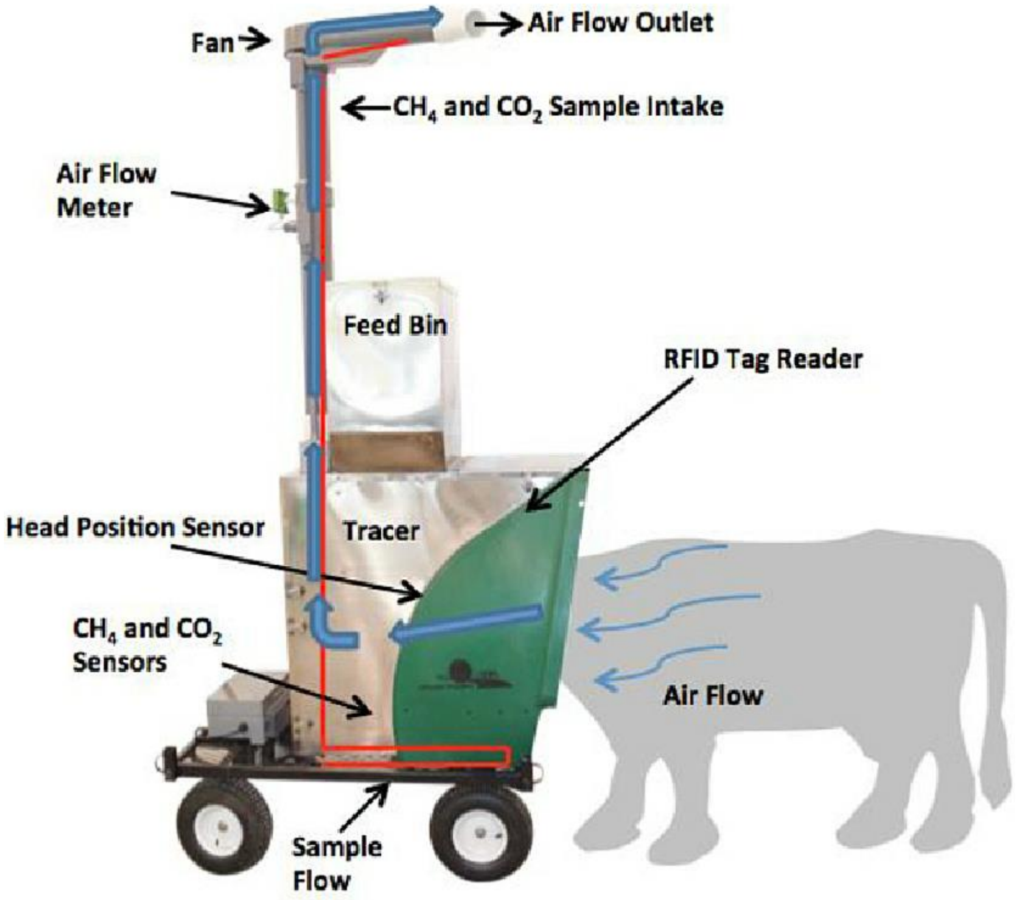
Milk fat and protein production in cows grazing canola



TMR = total mixed ration
CAN = canola

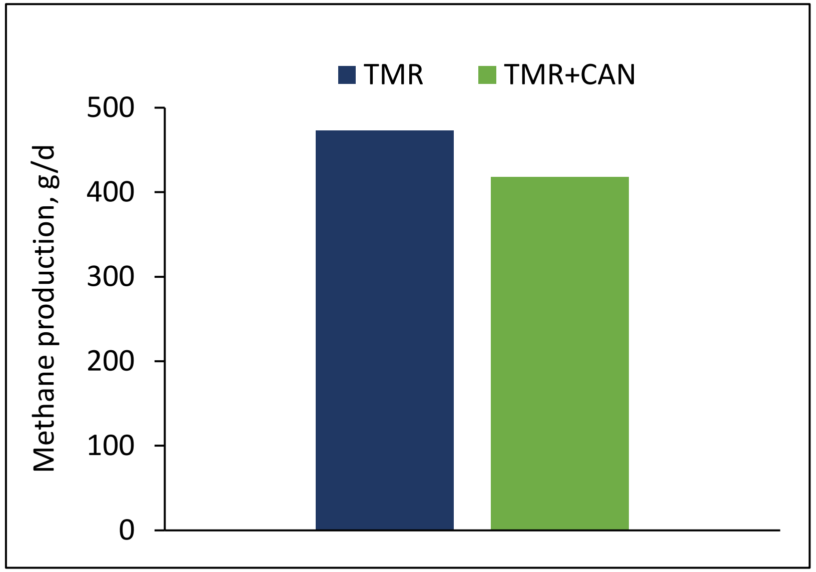
Methane emission measurements



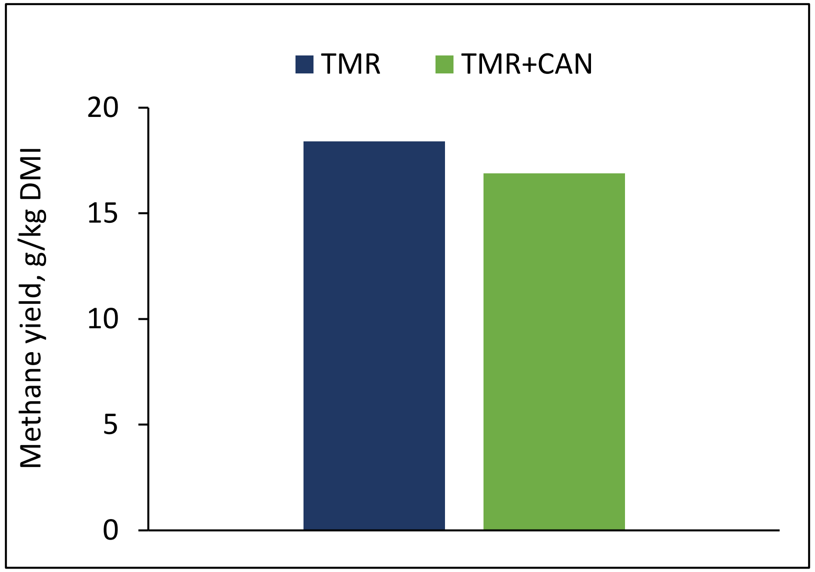
Methane emission measurements

Methane emission measurements

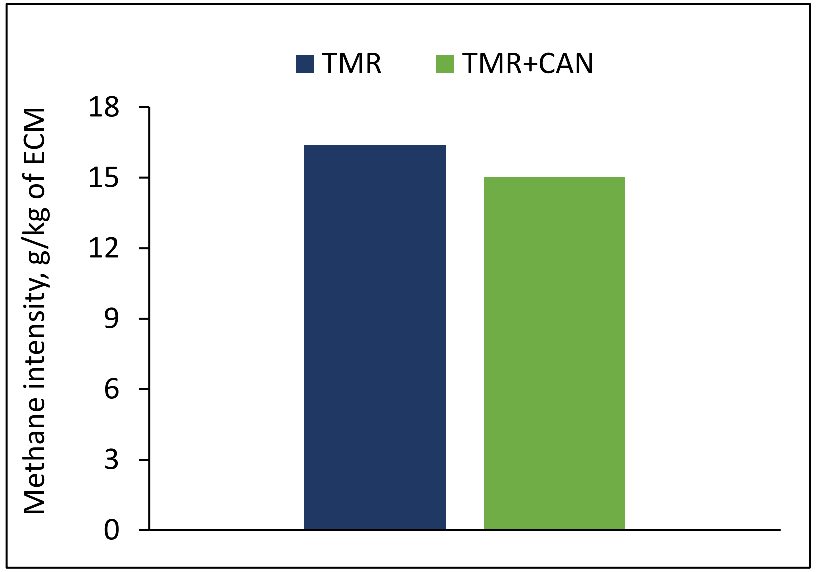
P < 0.01



P = 0.03



P = 0.02



TMR = total mixed ration
CAN = canola
DMI = dry matter intake
ECM = energy-corrected milk

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Summary

- Brassicas appear to have potential as a forage source for cattle grazing during fall
- Proportion of brassicas in dairy diets should not exceed 50% of the total DMI due to the presence of glucosinolates and potential milk “off-flavor”
- Costs and land use should be considered before adoption

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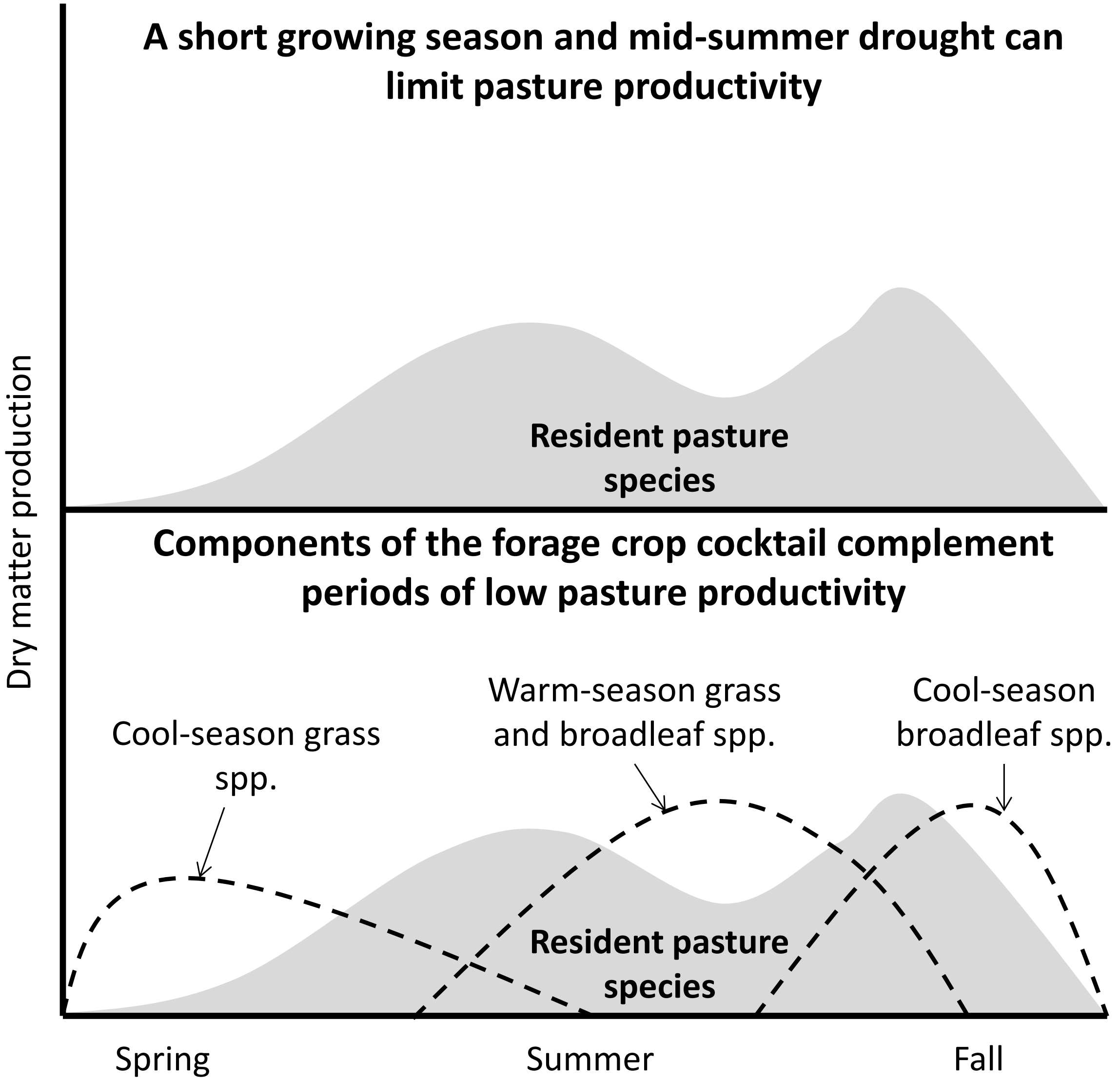
Use of summer annual forage crops for grazing



Botanical composition of traditional pasture and pasture stripped-tilled with annual forage crops (AFC)

	Week 1		Week 2		Week 3	
	Traditional	AFC	Traditional	AFC	Traditional	AFC
	-----------------------------% DM				-----------------------------	
Grasses	79	69	80	63	69	63
Legumes	4	7	5	8	11	13
Weeds	17	8	15	9	20	11
AFC-grasses	0	0	0	0	0	1
AFC-legumes	0	0	0	1	0	2
AFC-broadleaf	0	16	0	14	0	12

Summer AFC = buckwheat, teff, millet, oat, chickling vetch

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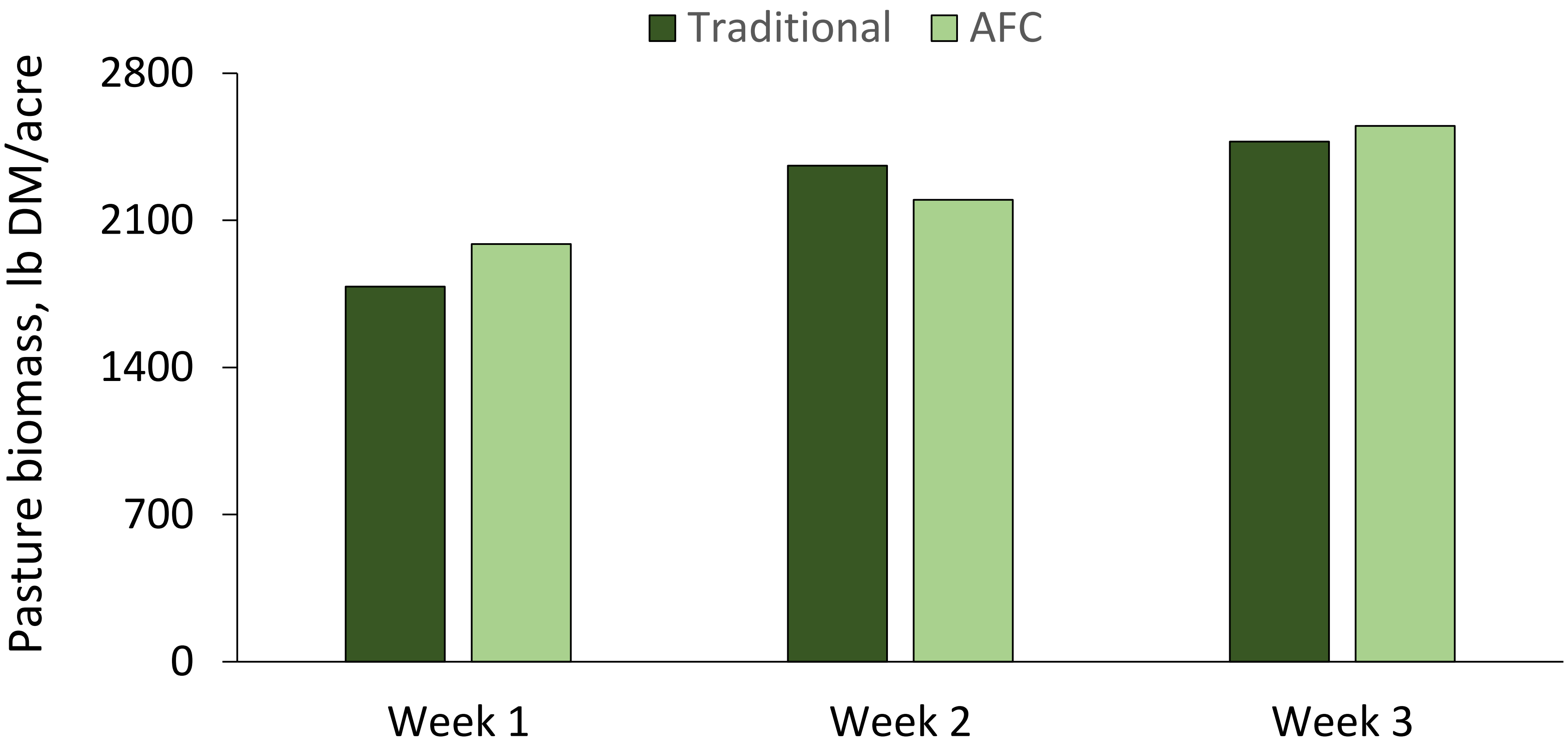
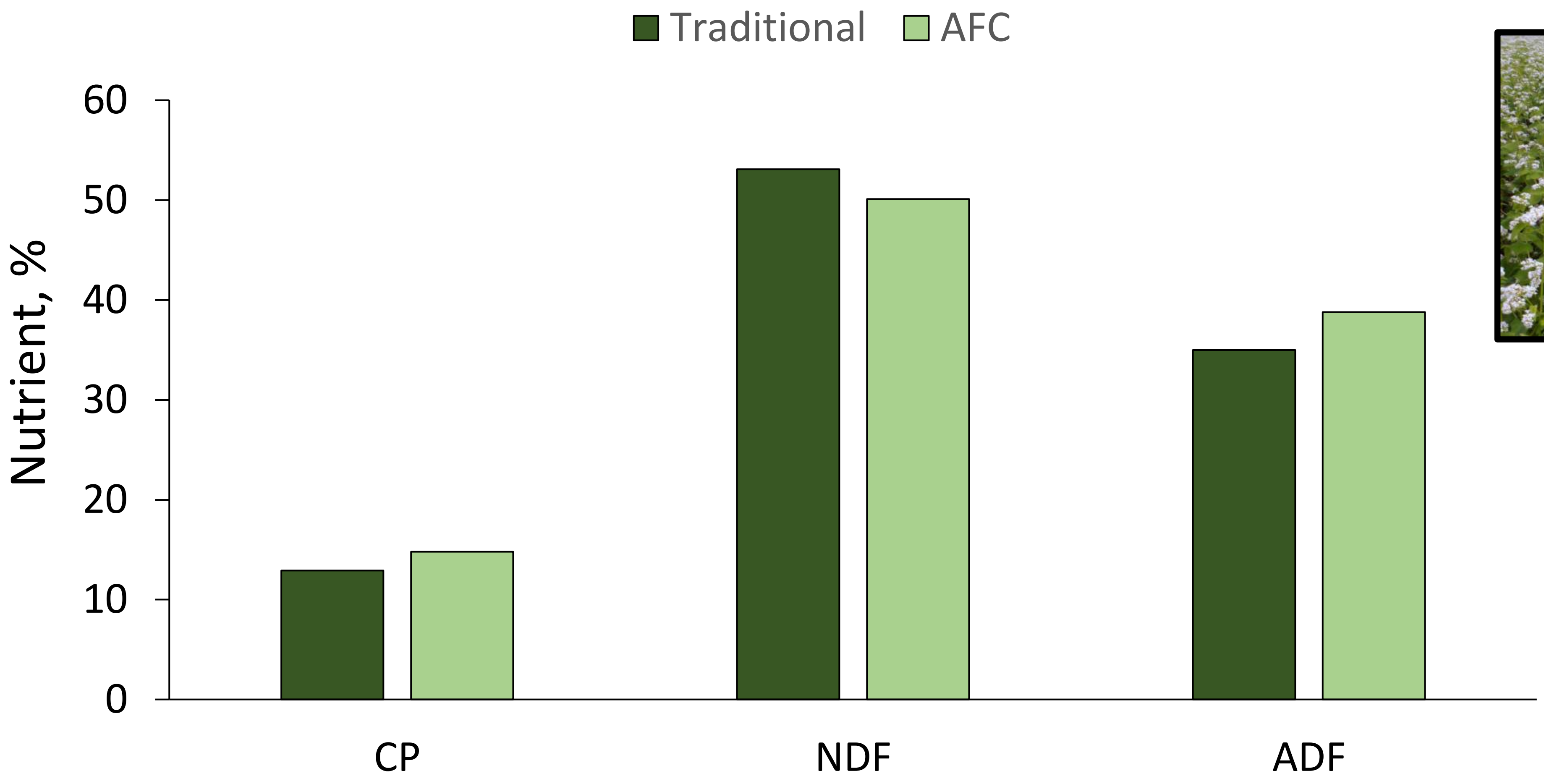
Biomass production of traditional pasture and pasture stripped-tilled with annual forage crops (AFC)



Nutrient composition of traditional pasture and pasture stripped-tilled with annual forage crops (AFC)



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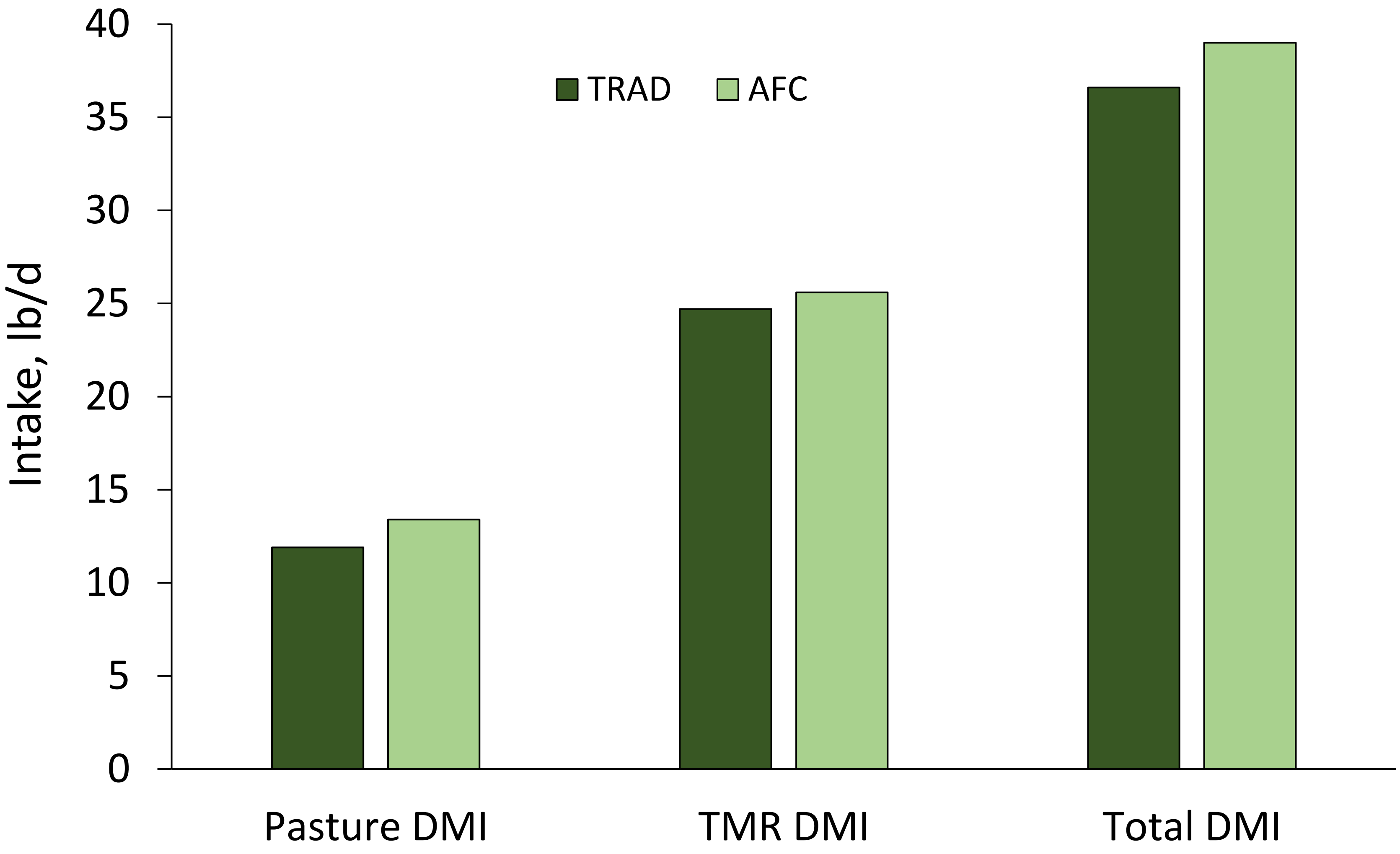
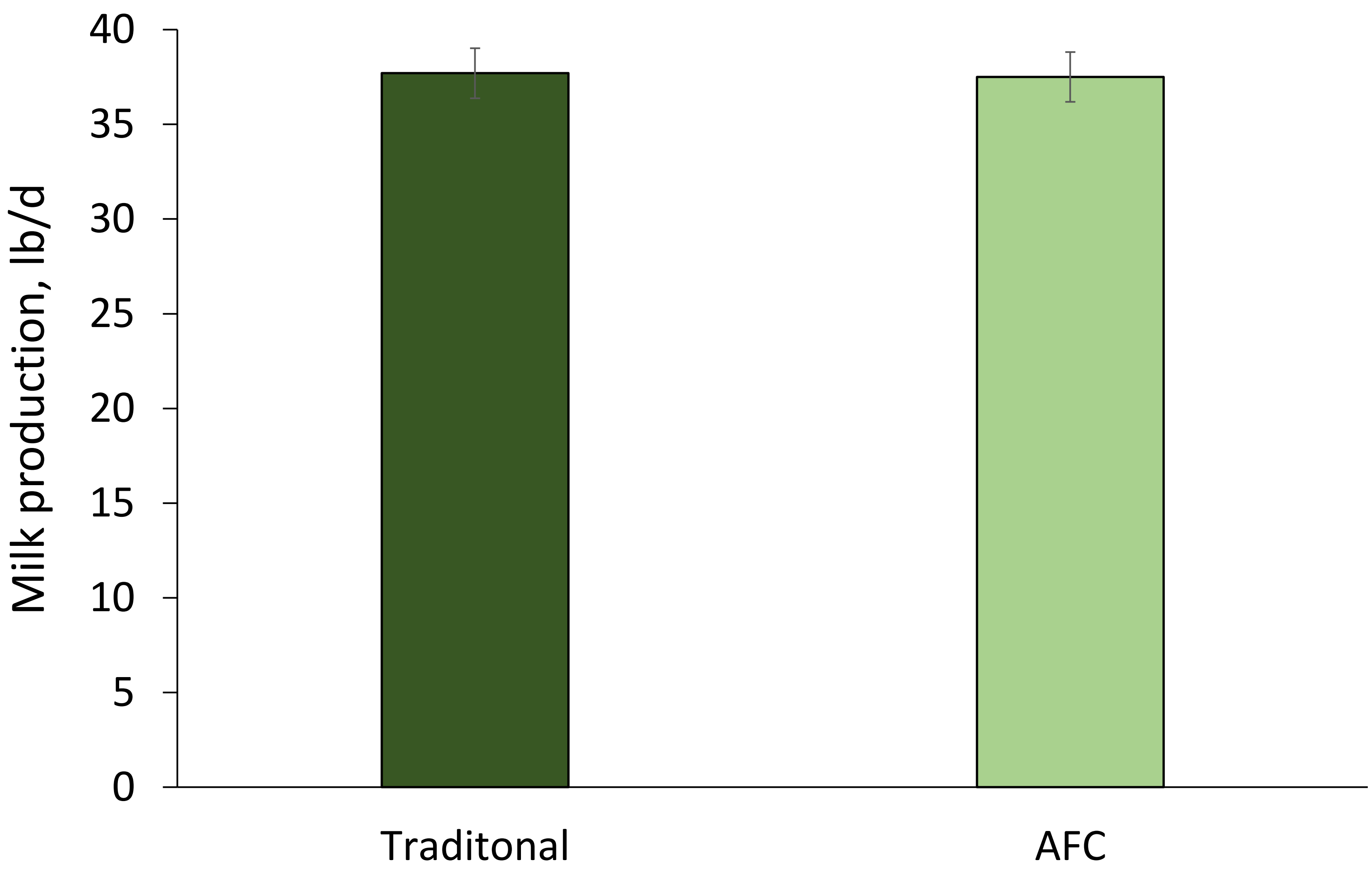
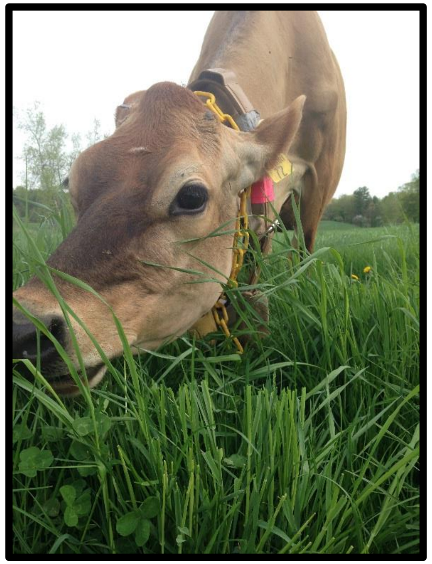
Intake in cows fed traditional pasture or pasture stripped-tilled with annual forage crops (AFC)



TRAD = traditional pasture

Milk production in cows fed traditional pasture or pasture stripped-tilled with annual forage crops (AFC)





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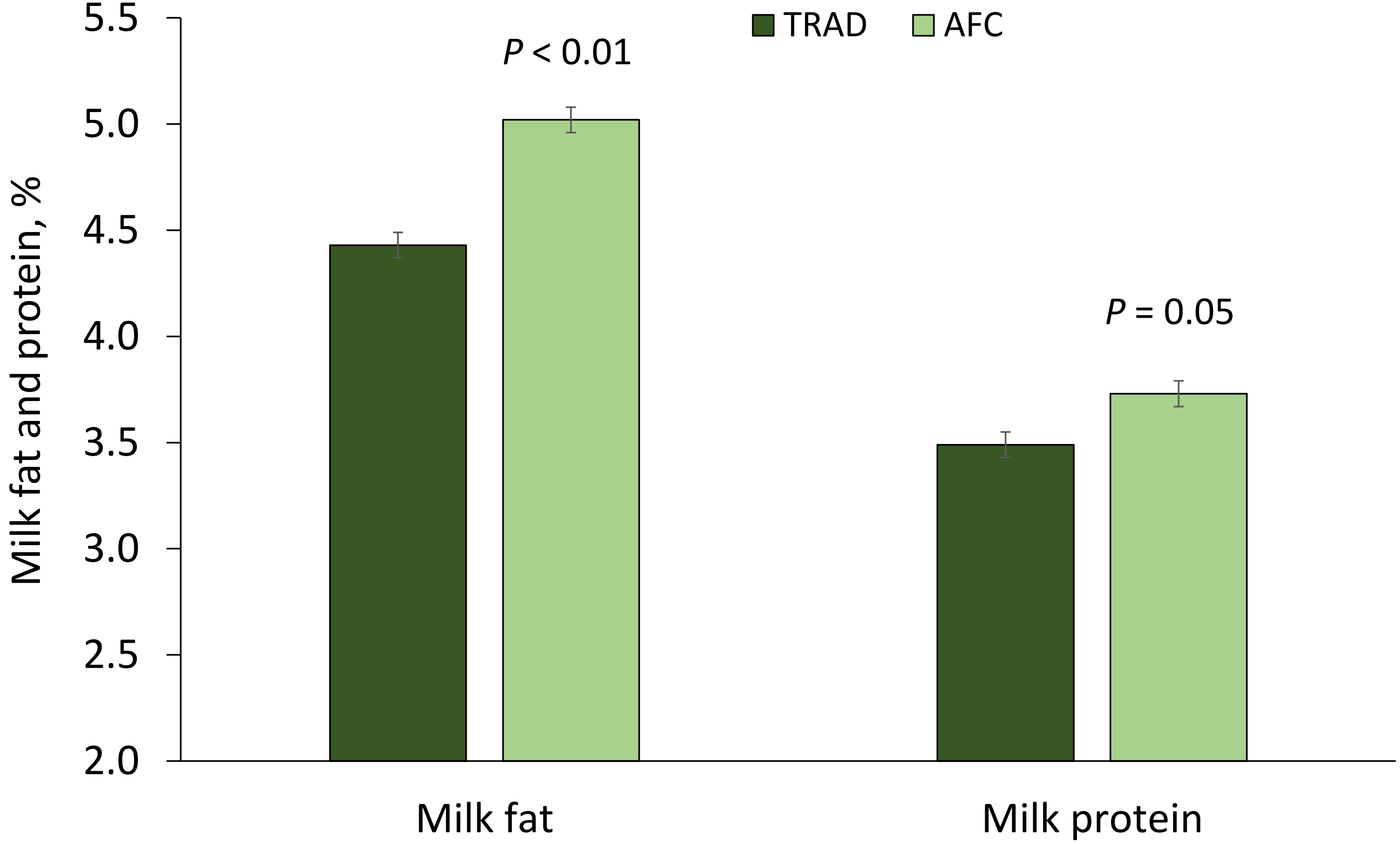
Milk fat and protein content in cows fed traditional pasture or pasture stripped-tilled with annual forage crops (AFC)



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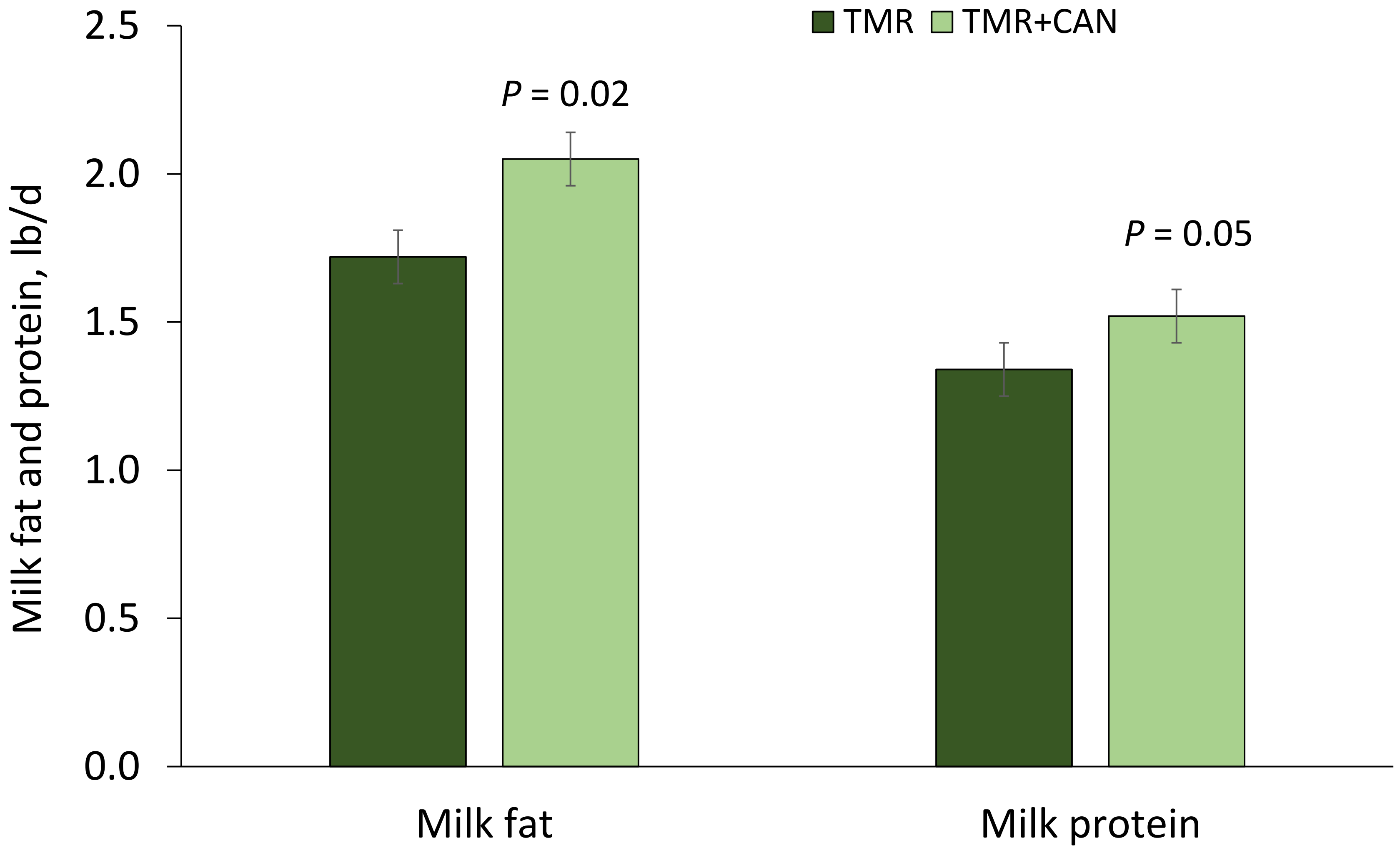
Milk fat and protein production in cows fed traditional pasture or pasture stripped-tilled with annual forage crops (AFC)



TRAD = traditional pasture

The Professional Animal Scientist 32 (2016):523–530; http://dx.doi.org/10.15232/pas.2015-01500

CASE STUDY: Feeding strategy and pasture quality relative to nutrient requirements of dairy cows in the northeastern United States

A. N. Hafla,* PAS, K. J. Soder,*1 PAS, André F. Brito,† Richard Kersbergen,‡ Fay Benson,§ Heather Darby,# Melissa Rubano,* and Simone F. Reis†

Table 2. Summary statistics (n = 380) of forage quality parameters and macro minerals and the effect of year, month, and farm on forage quality and macro mineral concentration of pastures in 2012, 2013, and 2014

					P-value		
Item	Mean[1]	SD[1]	Min[1]	Max[1]	Year	Month	Farm
Forage quality							
CP, %	19.5	4.10	6.60	32.4	0.25	<0.01	<0.01
ADF, %	31.4	4.79	18.0	73.0	0.75	<0.01	<0.01
NDF, %	51.0	8.67	24.2	71.0	<0.01	<0.01	<0.01
NE_l, Mcal/kg	1.39	0.15	0.77	1.76	0.03	<0.01	<0.01
Macro minerals[2]							
Ca, %	0.76	0.25	0.19	1.66	<0.01	<0.01	<0.01
P, %	0.36	0.08	0.07	1.04	0.23	<0.01	<0.01
Mg, %	0.28	0.06	0.10	0.46	<0.01	<0.01	<0.01
K, %	2.68	0.60	0.26	4.69	0.02	0.03	<0.01
S, %	0.28	0.05	0.09	0.44	0.14	<0.01	<0.01

[1]Mean, SD, minimum (Min), and maximum (Max) values across all farms and all months sampled in 2012, 2013, and 2014.

[2]Near-infrared reflectance spectroscopy analysis for sodium was missing on many samples; therefore, it is not included.

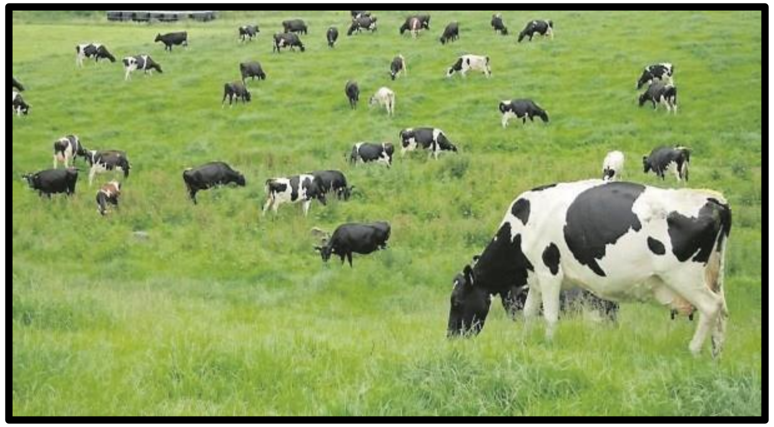


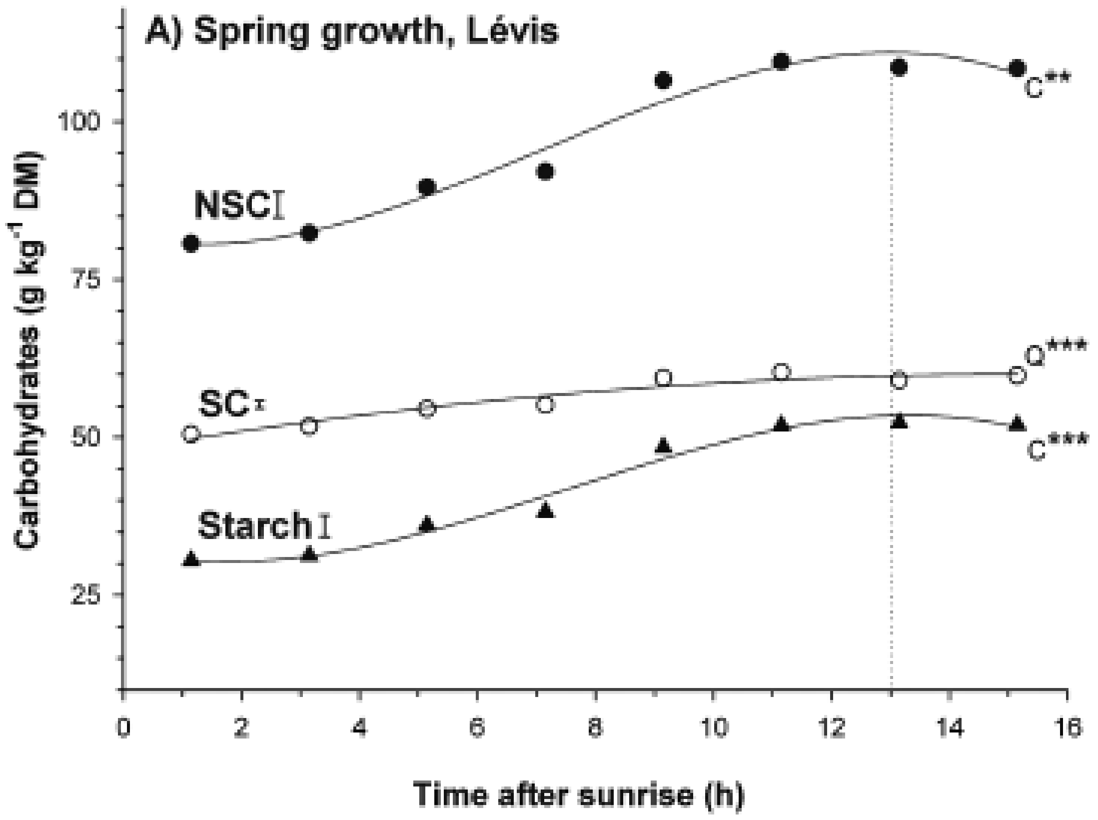
Table 3. Crude protein, fiber, energy, and macro mineral recommendations for lactating dairy cows and the frequency of pastures that did not meet minimum (min) dietary requirements

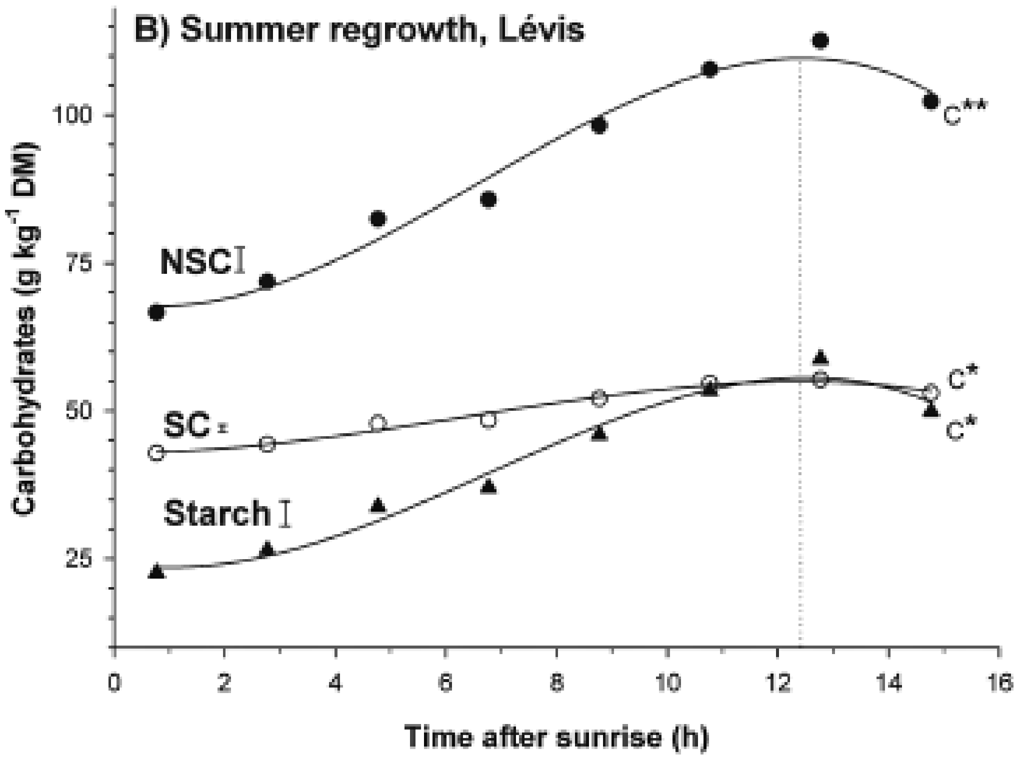
Item	Animal requirements according to Dairy NRC (2001), % of total diet, unless otherwise noted		Samples not meeting min animal requirements, %, unless otherwise noted	
	680-kg Holstein,[1] 25 kg/d milk	454-kg Jersey,[2] 25 kg/d milk	680-kg Holstein,[1] 25 kg/d milk	454-kg Jersey,[2] 25 kg/d milk
Forage quality				
CP	14.1	16.1	9.21	20.8
ADF	17–21 min	17–21 min	0.00	0.00
NDF	25–33 min	25–33 min	0.00	0.00
NE_L, Mcal/kg	1.37	1.54	35.5	85.8
Macrominerals				
Calcium	0.62	0.57	30.8	22.1
Phosphorus	0.32	0.33	19.2	26.1
Magnesium	0.18	0.18	2.89	2.89
Potassium	0.24	0.24	0.00	0.00
Sulfur	0.22	0.20	11.1	6.58

[1]Additional cow parameters used in NRC (2001) model to estimate requirements: BCS = 3.0, 65 mo of age, milk fat = 3.5%, milk protein = 3.0%, default environmental conditions (confinement, tie stall, TMR).

[2]Additional cow parameters used in NRC (2001) model to estimate requirements: BCS = 3.0, 65 mo of age, milk fat = 4.2%, milk protein = 3.6%, default environmental conditions (confinement, tie stall, TMR).

Diurnal variation in sugars and starch in alfalfa





NSC – non-structural carbohydrates
SC = soluble carbohydrates

J. Dairy Sci. 91:3968–3982
doi:10.3168/jds.2008-1282

Alfalfa Cut at Sundown and Harvested as Baleage Improves Milk Yield of Late-Lactation Dairy Cows[1]

A. F. Brito,* G. F. Tremblay,† A. Bertrand,† Y. Castonguay,† G. Bélanger,† R. Michaud,† H. Lapierre,* C. Benchaar,* H. V. Petit,* D. R. Ouellet,* and R. Berthiaume*[2]
*Dairy and Swine Research and Development Centre, Agriculture and Agri-Food Canada, Sherbrooke, Québec, Canada J1M 1Z3
†Soils and Crops Research and Development Centre, Agriculture and Agri-Food Canada, Québec, Québec, Canada G1V 2J3

Sugars and starch in PM- vs. AM-cut alfalfa baleage

Item[1]	Time of cutting PM	Time of cutting AM	SED[2]	*P*-value[3]
DM, g/kg of fresh matter	537	524	15.4	0.44
	g/kg of DM			
TNC[4]	128	105	3.00	<0.01
Total reducing sugars	89.0	67.5	2.30	<0.01
Pinitol	22.0	26.0	0.80	<0.01
Starch	17.1	11.4	0.67	<0.01
WSC[5]	111	93.5	2.50	<0.01

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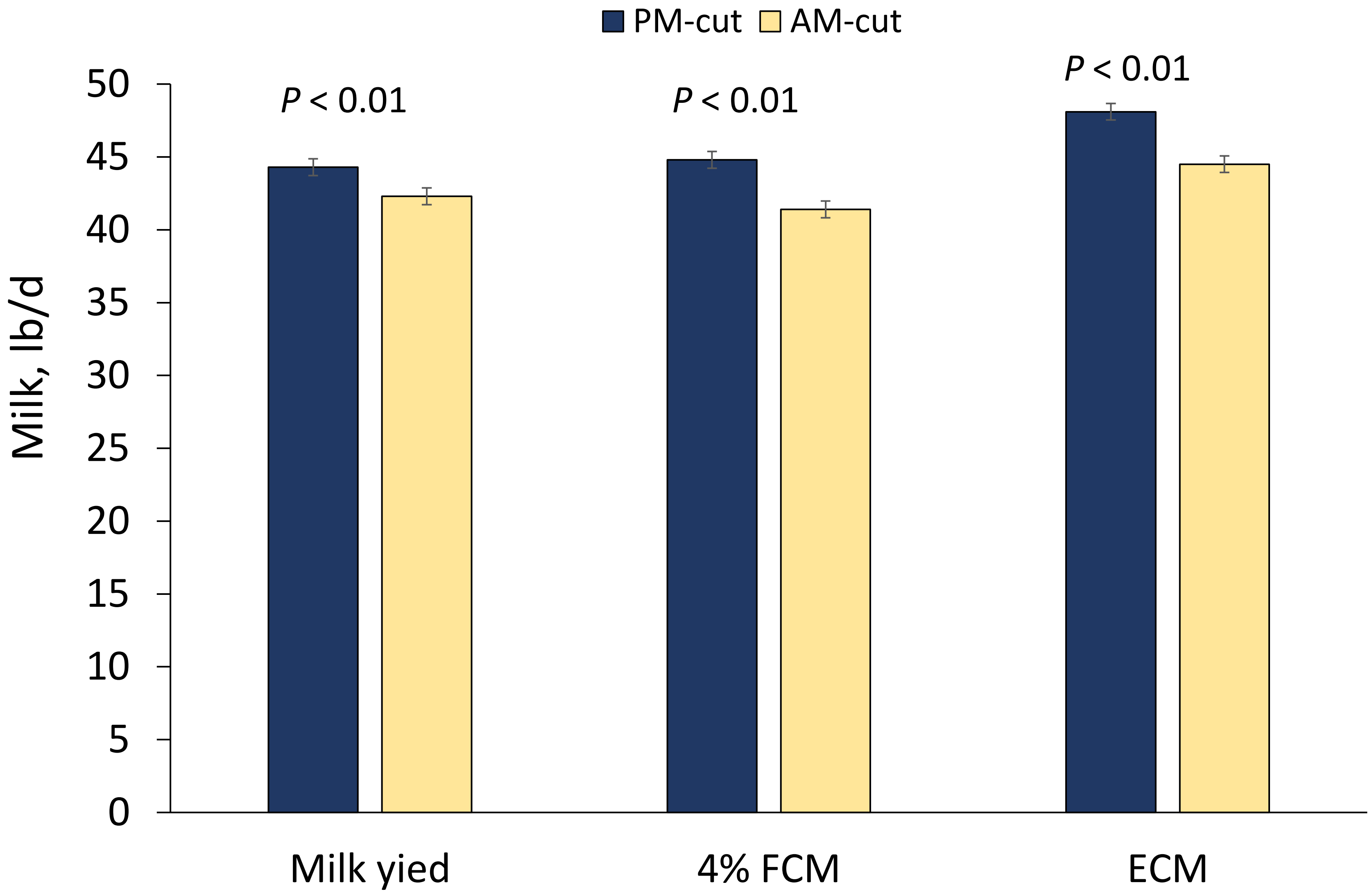
Milk production in cows fed PM-cut alfalfa baleage



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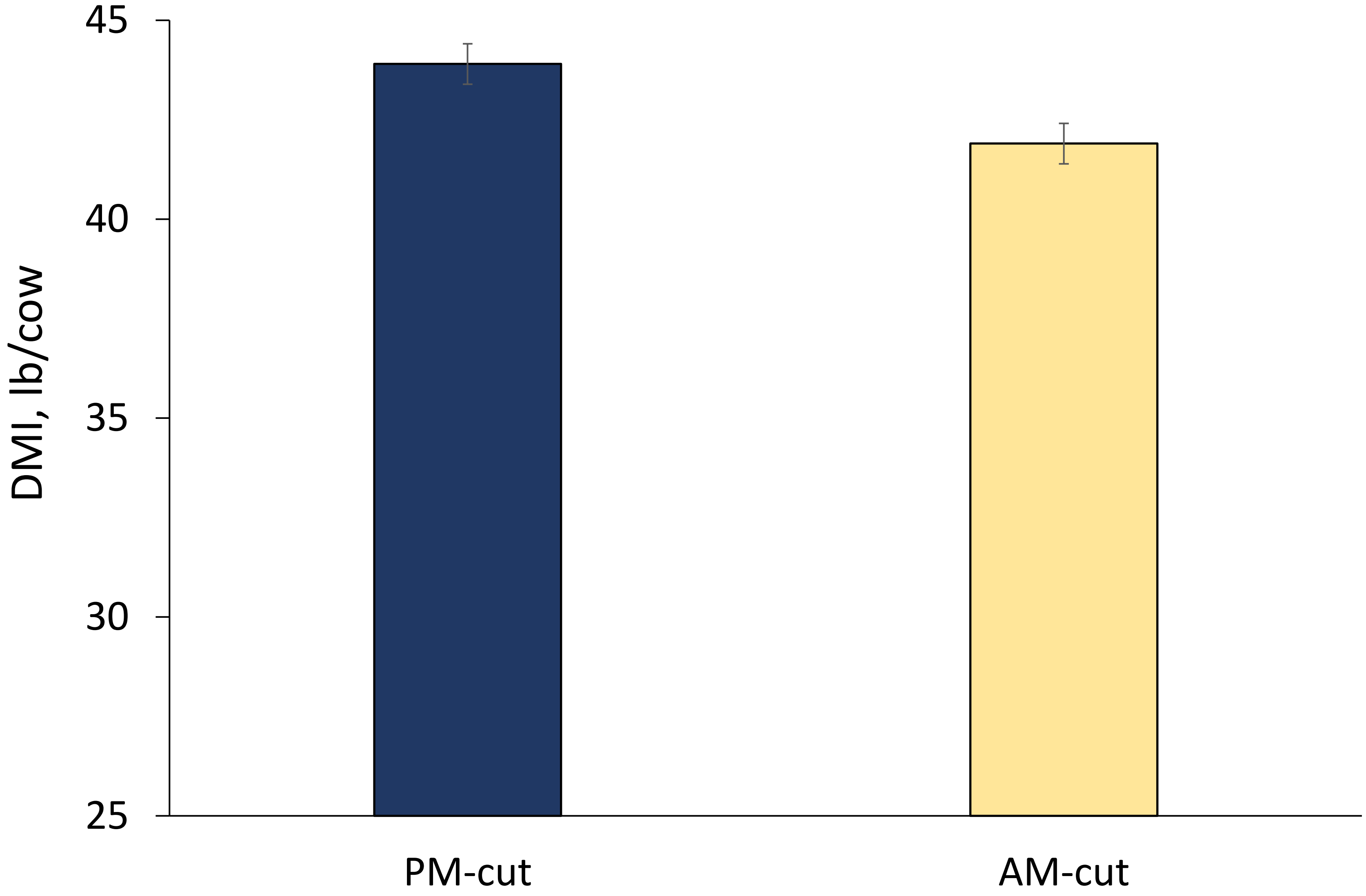
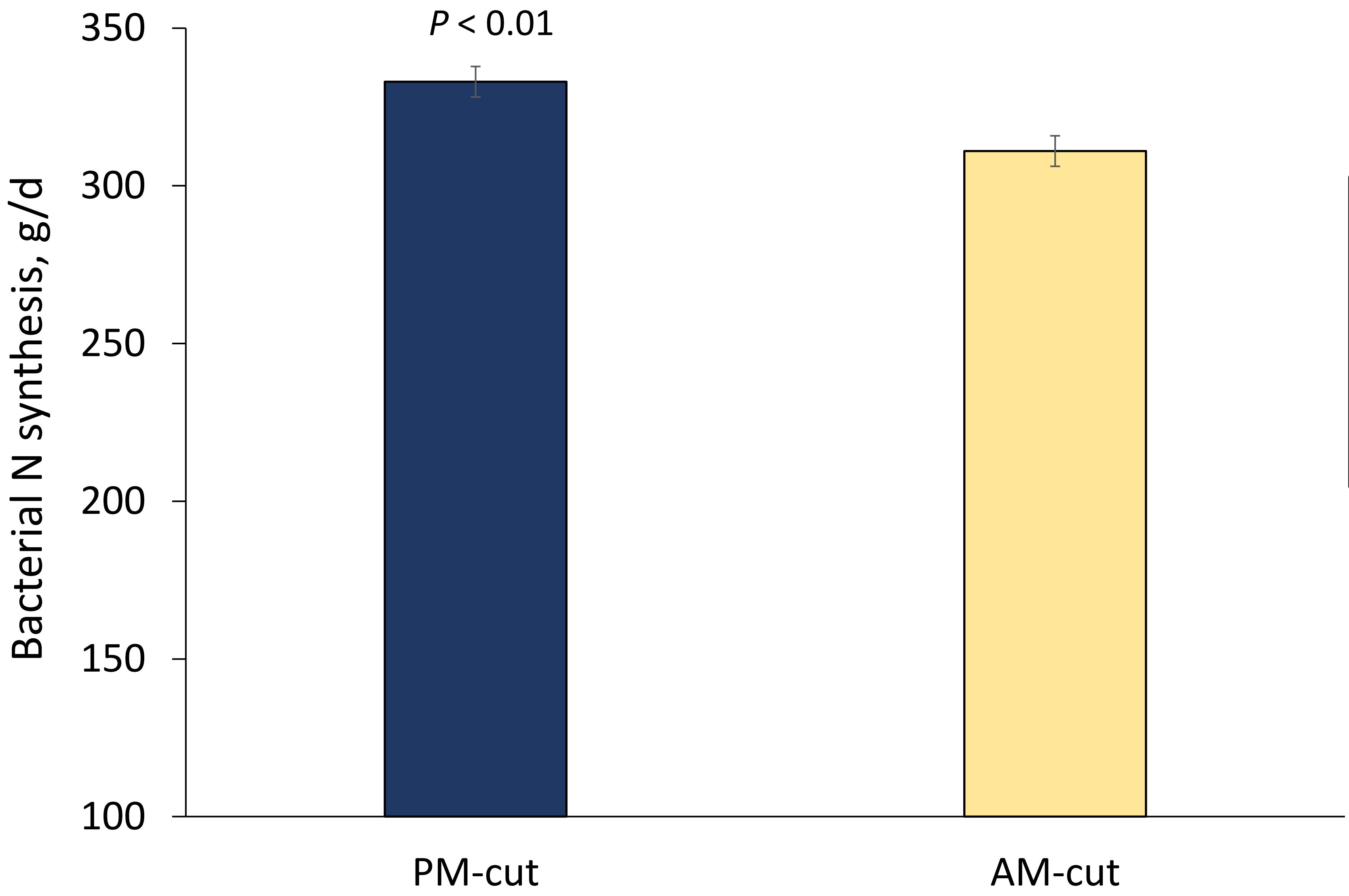
DMI in dairy cows fed PM-cut alfalfa baleage



Bacteria N synthesis in dairy cows fed PM-cut alfalfa baleage



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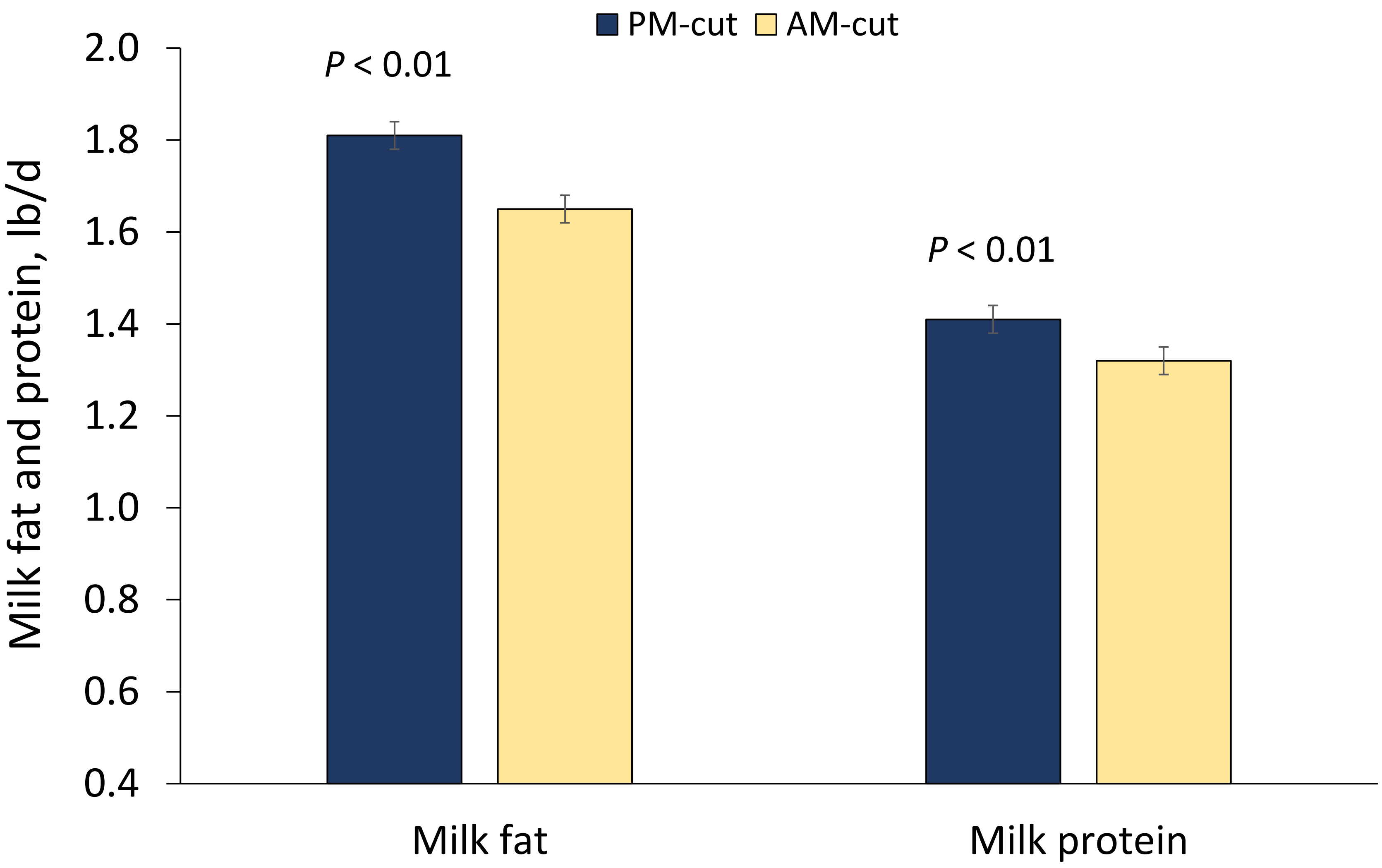
Milk fat and protein production in cows fed PM-cut alfalfa baleage



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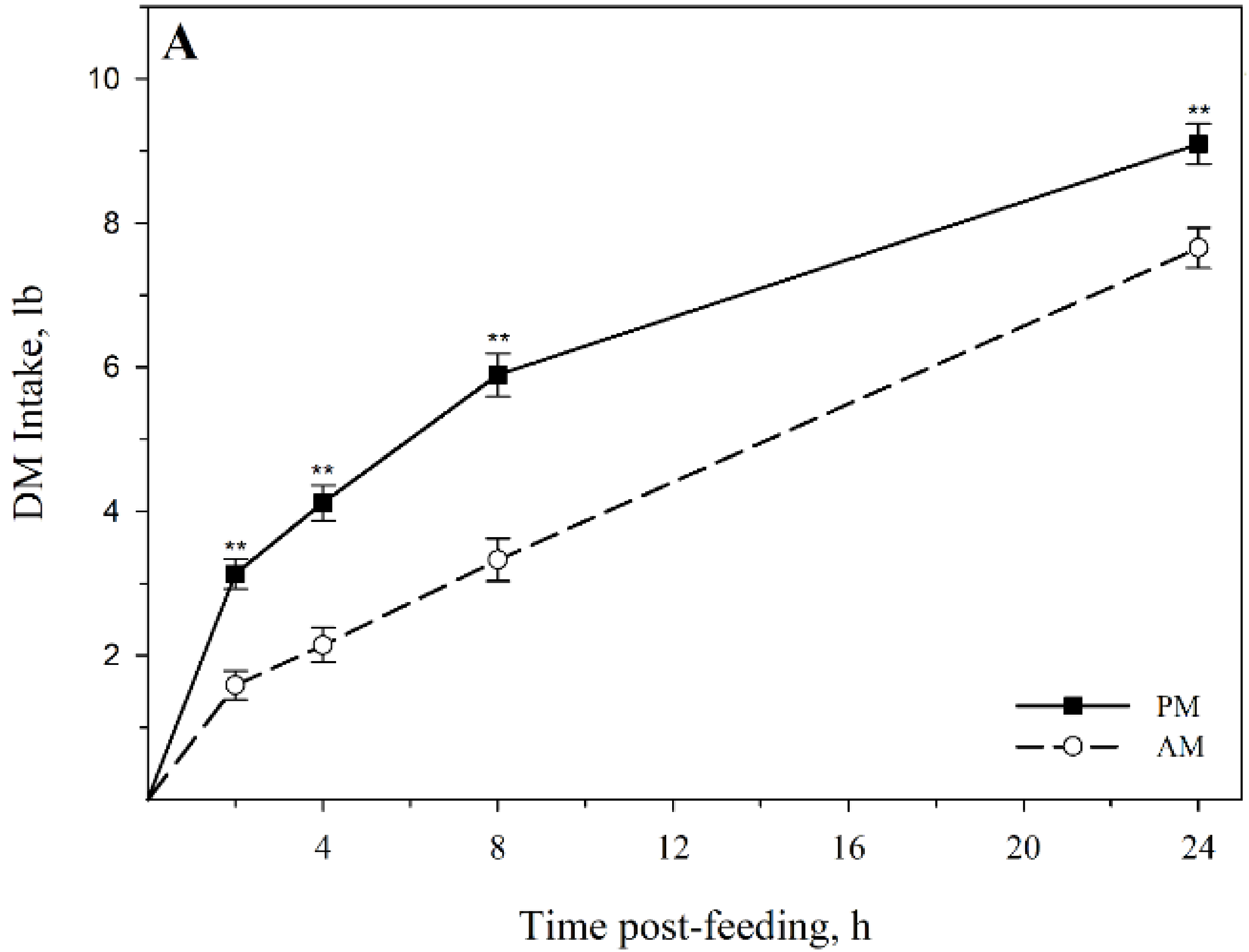
DMI disappearance in beef steers fed PM-cut birdsfoot trefoil hay



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Summary

- PM-cutting and PM-grazing can result in forage sources with increased concentrations of sugars and starch, which ultimately improve milk production and weigh gain in cattle

- Increased energy concentration through PM-cutting and PM-grazing may be a strategy to reduce feed costs

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Frequency of pastures that did not meet minimum requirements

Item	Animal requirements according to Dairy NRC (2001), % of total diet, unless otherwise noted		Samples not meeting min animal requirements, %, unless otherwise noted	
	680-kg Holstein,[1] 25 kg/d milk	454-kg Jersey,[2] 25 kg/d milk	680-kg Holstein,[1] 25 kg/d milk	454-kg Jersey,[2] 25 kg/d milk
Forage quality				
CP	14.1	16.1	9.21	20.8
ADF	17–21 min	17–21 min	0.00	0.00
NDF	25–33 min	25–33 min	0.00	0.00
NE_l, Mcal/kg	1.37	1.54	35.5	85.8
Macrominerals				
Calcium	0.62	0.57	30.8	22.1
Phosphorus	0.32	0.33	19.2	26.1
Magnesium	0.18	0.18	2.89	2.89
Potassium	0.24	0.24	0.00	0.00
Sulfur	0.22	0.20	11.1	6.58

n = 380 pasture samples collected from 2012-1015 in organic dairies in NH, VT, ME, NY, and PA
CP = crude protein, ADF = acid detergent fiber, NDF = neutral detergent fiber, NE_l = net energy of lactation; Source: Hafla et al. (2016)

Kelp meal supplementation

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Kelp meal nutritional properties

- Brown seaweed (*Ascophyllum nodosum*) rich in minerals, particularly iodine (Antaya et al., 2015)
- Contains a wide spectrum of nutritional compounds including polyunsaturated fatty acids (PUFA), polyphenols, bioactive peptides, and vitamins (Kumari et al., 2010; Tierney et al., 2010; Fitzgerald et al., 2011)
- Rich in phlorotannin, a polyphenol similar to terrestrial tannins known to affect carbohydrate and protein utilization, and to inhibit bacterial growth (Ragan and Glombitza,1986; Wang et al., 2008, 2009)
- High concentrations of antioxidants such as β-carotene and fucoxanthine, which may improve animal health (Haugan and Liaaen-Jensen, 1994; Allen et al., 2001)

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Use of kelp meal in organic dairy farms in the Northeast and Midwest US

- 59% of organic dairy farmers feed kelp meal in the Northeast (Antaya et al., 2015)
- 49% of organic dairy farmers feed kelp meal in Wisconsin (Hardie et al., 2014)
- 83% of organic dairy farmers feed kelp meal in Minnesota (Sorge et al., 2016)

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Why organic dairy farmers feed kelp meal in the Northeast?

- It improves body condition and overall animal appearance
- It decreases milk somatic cell count, reproductive problems, and incidence of “pinkeye” (i.e., infectious bovine keratoconjunctivitis)
- It helps with control of nuisance flies during the grazing season

Source: Antaya et al. (2015)

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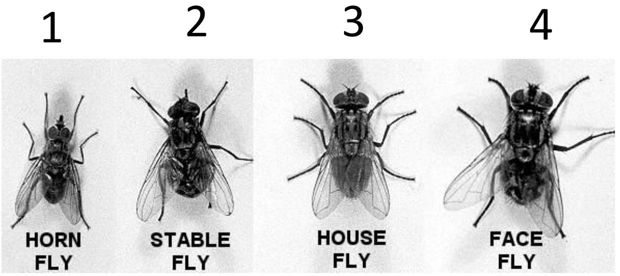

1. *Haematobia irritans* L.,
2. *Stomoxys calcitrans* L.
3. *Musca domestica*
4. *Musca autumnalis*, De Geer

Source: Denning et al. 2014

Pasture vs. kelp meal nutritonal composition

	Feeds	
Item	**Pasture**	**Kelp meal**
CP	19.5	10.2
NDF	51.0	53.9
ADF	31.4	39.9
Ca	0.76	1.31
P	0.36	0.25
Mg	0.28	0.69
K	2.68	3.53
S	0.28	2.84
I, ppm	0.62	820

Sources: Antaya et al. 2015; Hafla et al. (2016); Brito et al. (unpublished)

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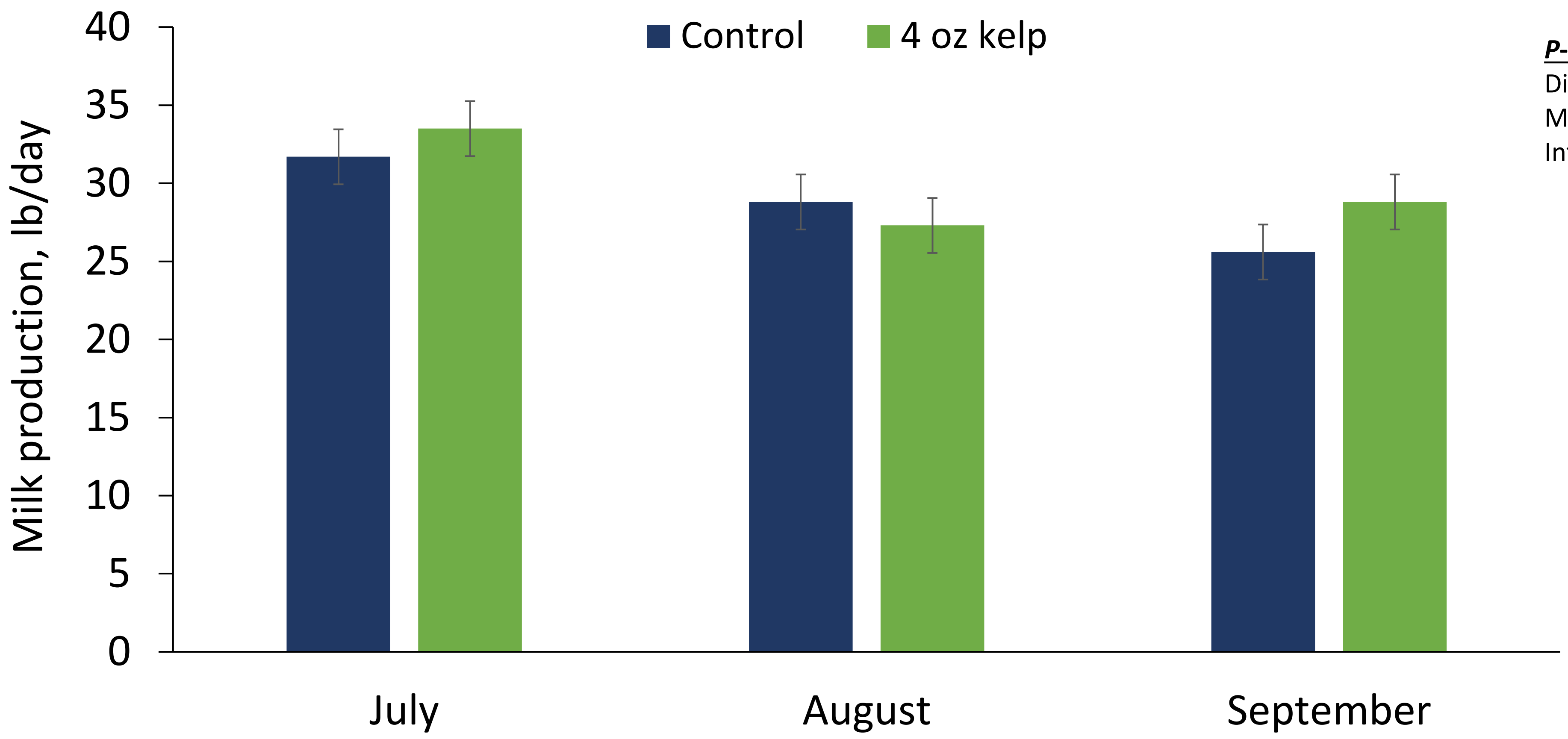
Milk production in grazing cows fed kelp meal



***P*-values**
Diet ($P = 0.59$)
Month ($P < 0.001$)
Interaction ($P = 0.19$)

Source: Brito et al. (unpublished)

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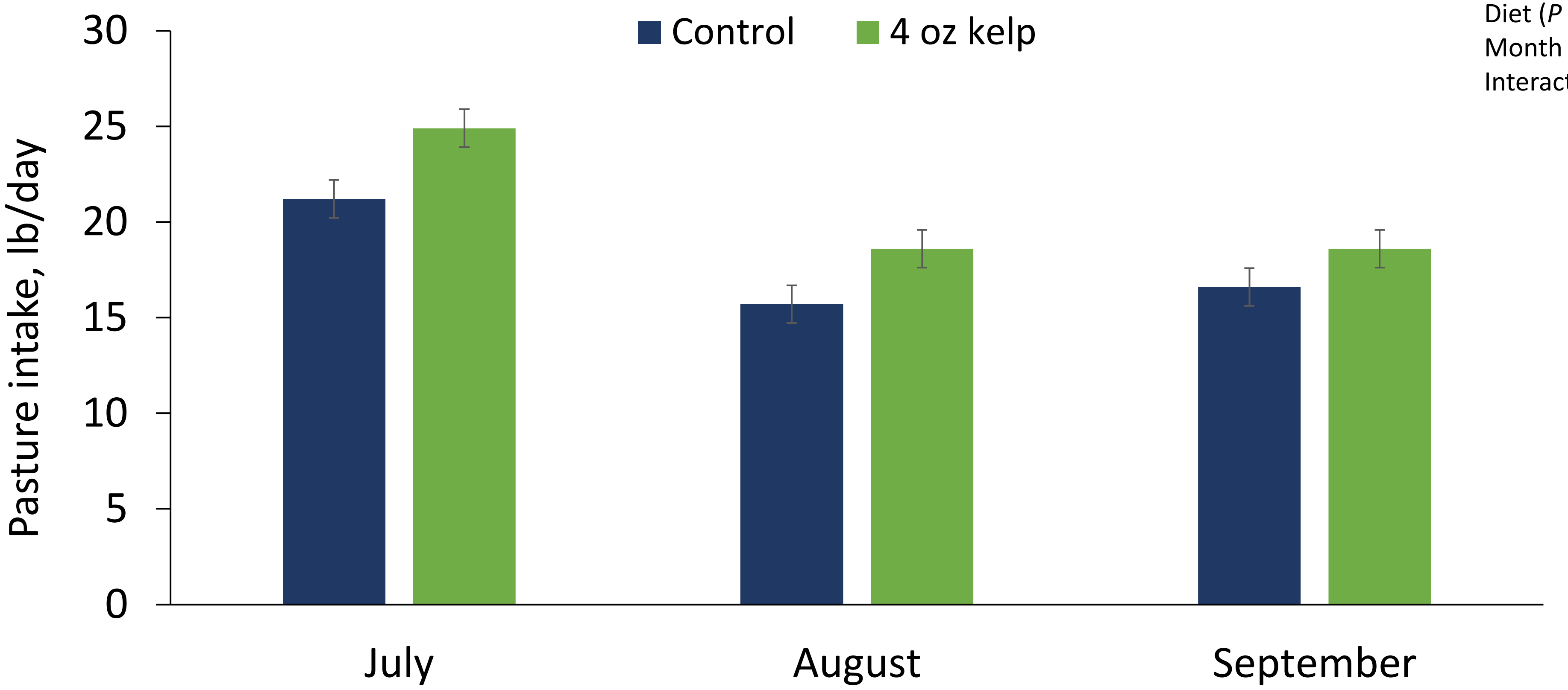
Pasture intake in grazing cows fed kelp meal



***P*-values**
Diet ($P = 0.05$)
Month ($P < 0.001$)
Interaction ($P = 0.73$)

Source: Brito et al. (unpublished)

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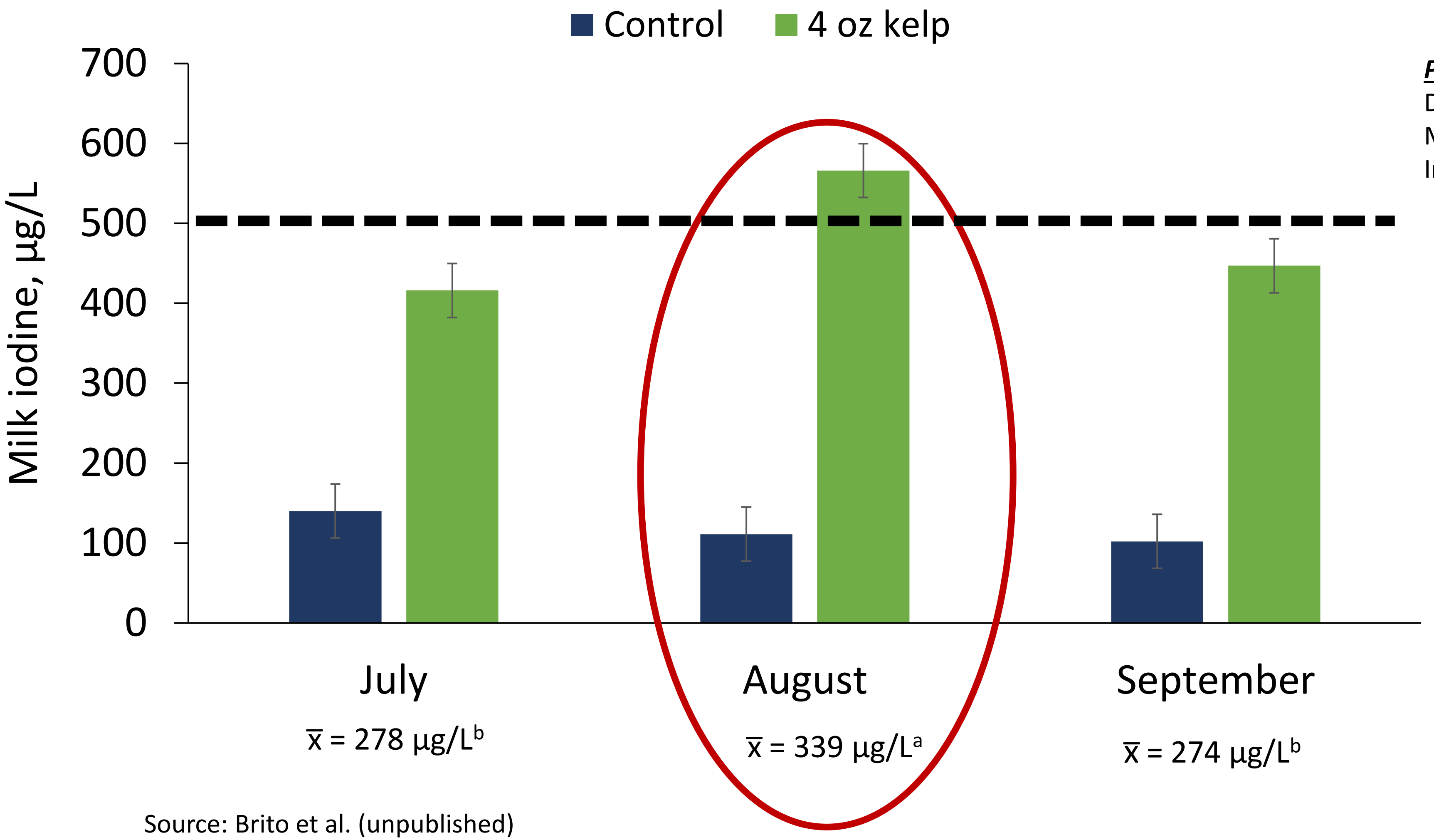
Milk iodine concentration in grazing cows fed kelp meal



***P*-values**
Diet ($P < 0.001$)
Month ($P < 0.01$)
Interaction ($P < 0.01$)

Source: Brito et al. (unpublished)

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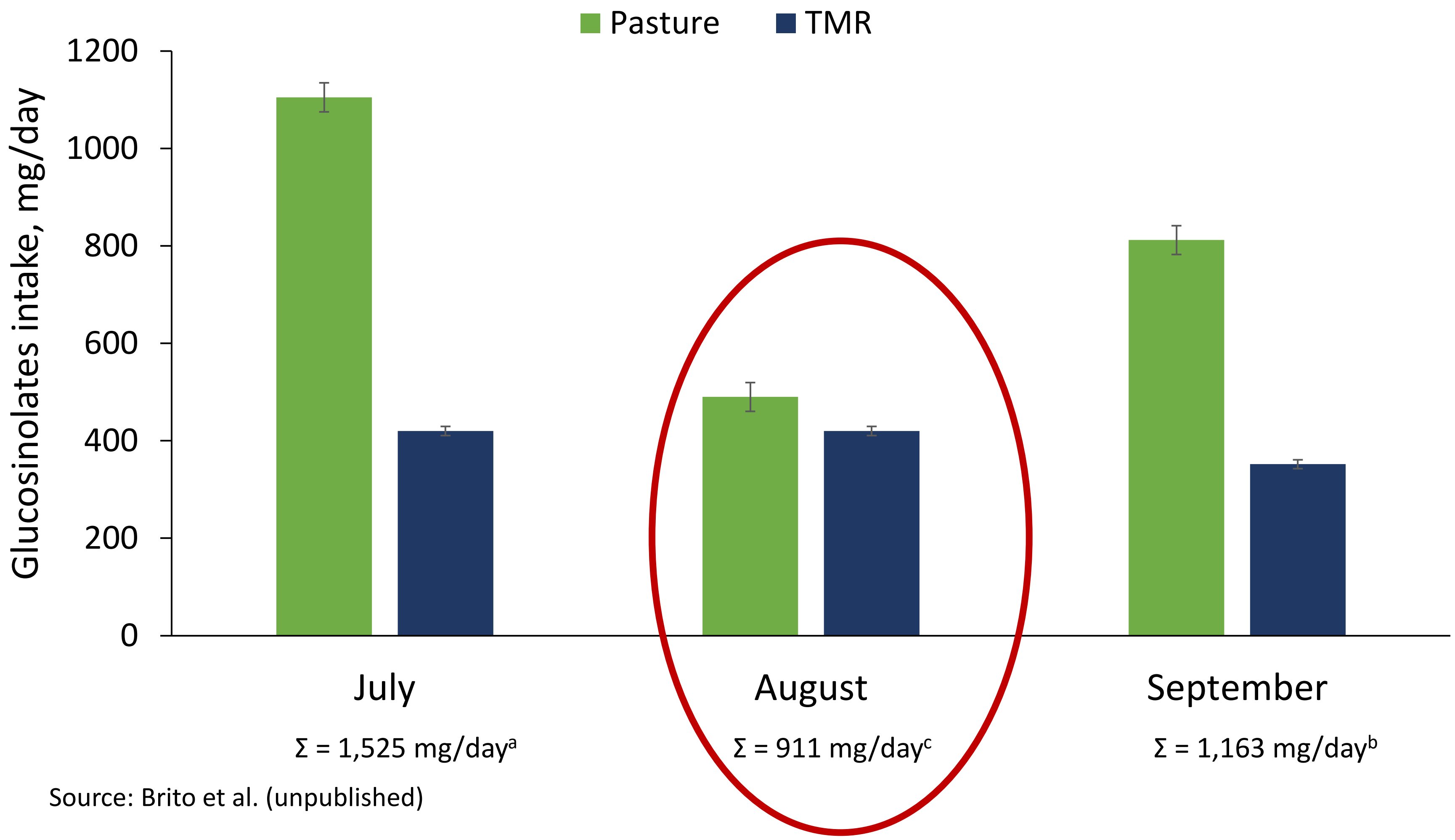
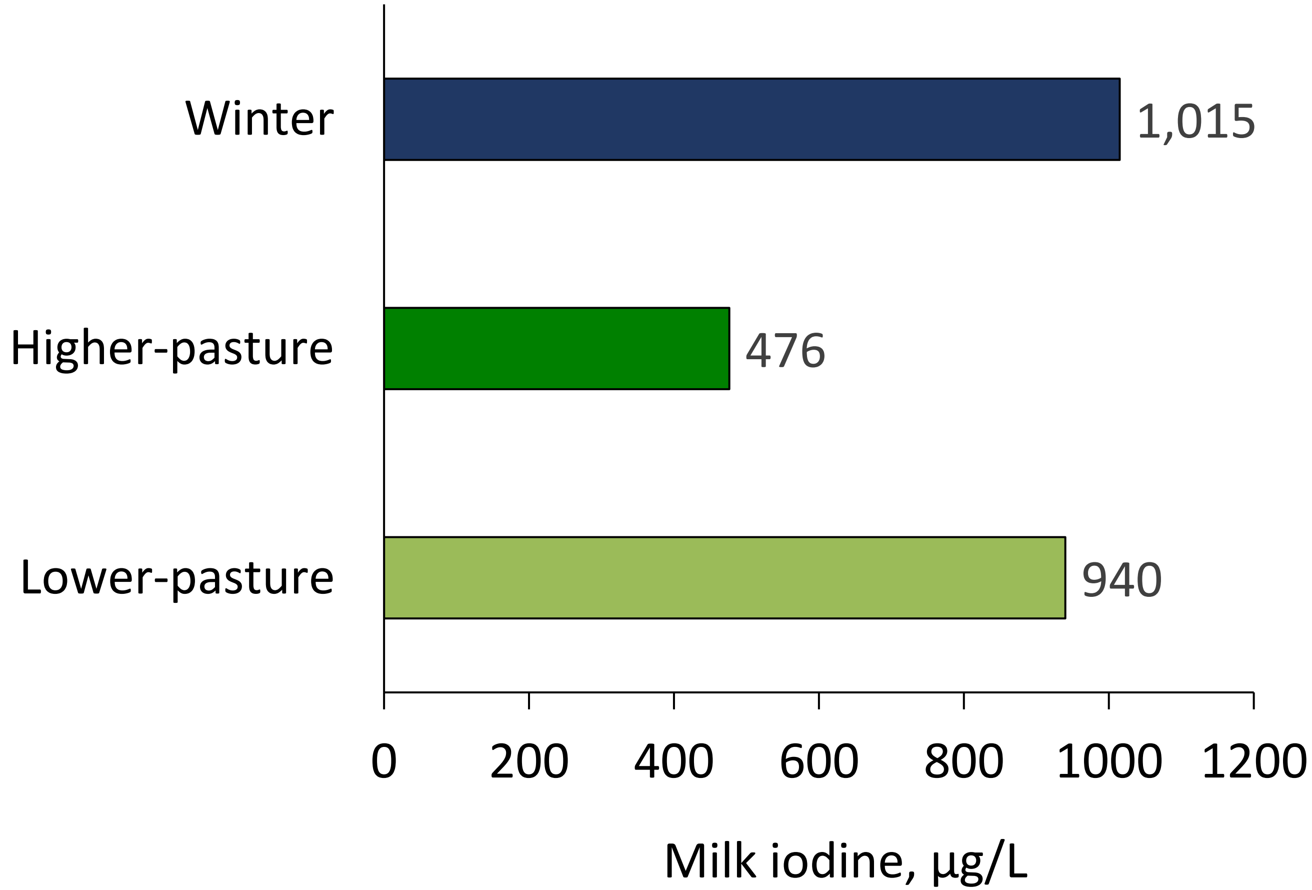
Glucosinolates intake during the grazing season



***P*-values**
Diet ($P = 0.09$)
Month ($P < 0.001$)
Interaction ($P = 0.40$)

Source: Brito et al. (unpublished)

Milk iodine concentration in dairy cows fed 4 oz of kelp meal during the winter[1] and summer seasons[2]



[1]Winter study: Antaya et al. 2015

[2]Summer study: Brito et al. (unpublished)

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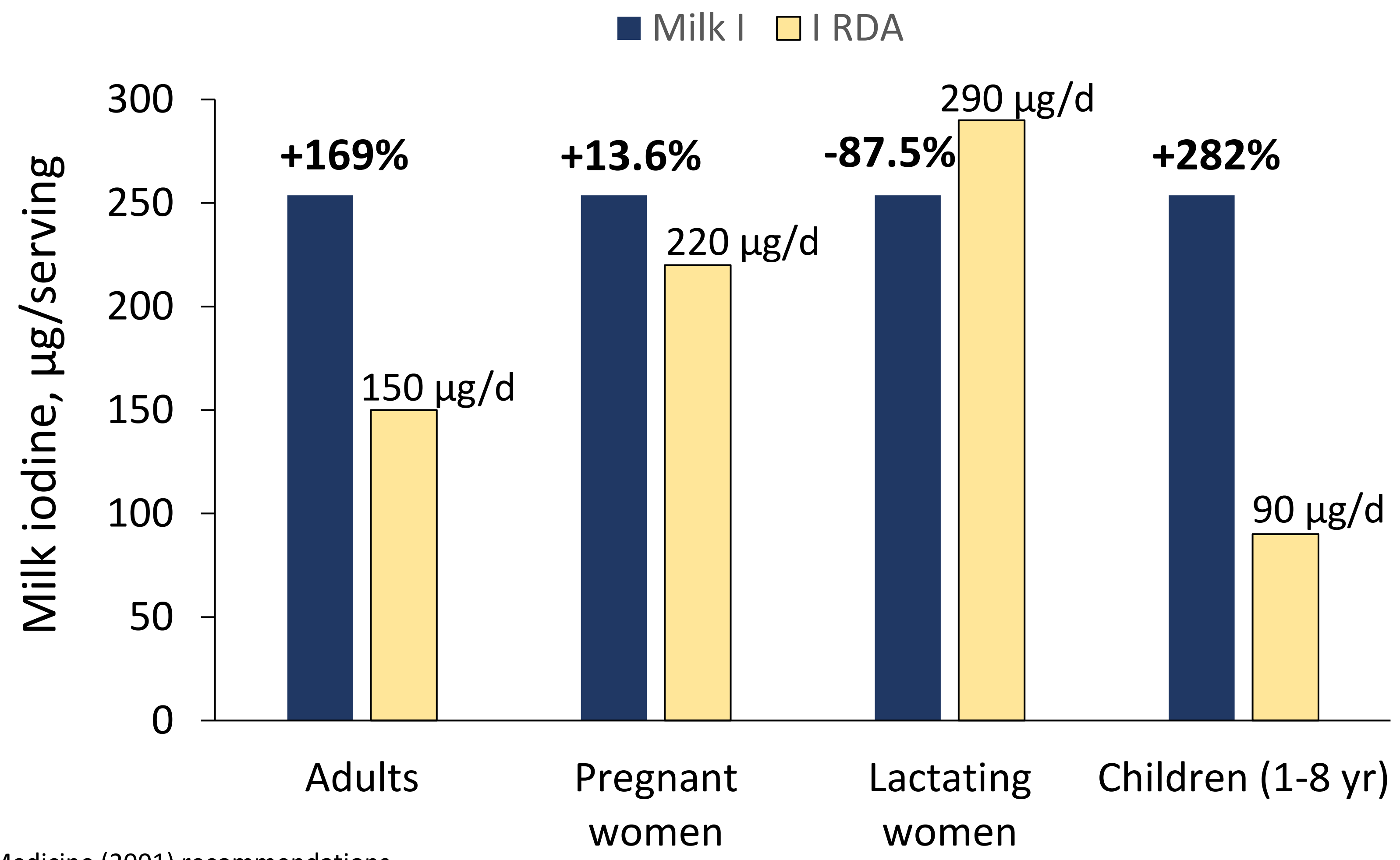
Iodine intake per serving of milk from cows fed 4 oz of kelp meal relative to iodine RDA[1]



[1]Based on the US Institute of Medicine (2001) recommendations
RDA = recommended dietary allowance

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Summary

- Kelp meal supplementation effectively increases the concentration of iodine in milk

- Therefore, there are concerns and opportunities regarding the impact of iodine in human health

- Kelp can be used as a mineral supplement for grazing cows, but costs should be considered

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Acknowledgments

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USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

SARE
Sustainable Agriculture Research & Education

GRANITE STATE GRAZIERS

Questions?


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